State and Industrial Actions to Influence Consumer Behavior

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To caffeine, music, and comfort food,
my friends by my side during many evenings spent writing.

Abstract

This thesis consists of an introductory part and four papers.

Paper [I] examines how taxes affect consumption of commodities that are detrimental to health and the environment: tobacco, alcoholic beverages, household energy, and petroleum fuel (petrol) for transportation. Specifically, this paper examines if a tax increase leads to a significantly larger change in consumption than a producer price change, which is referred to as the signaling effect from taxation. Through an empirical analysis using the Linear Almost Ideal Demand System, the analysis uses aggregated cross-sectional time series data and information on major legislation introductions in Sweden, Denmark and the United Kingdom from 1970 to 2009. We find the main result to be that the signaling effect is significant for "Electricity" in Sweden and Denmark and significant for "Electricity" and "Petrol" in the United Kingdom. This implies that tax policy is more effective in tackling consumption of commodities which produce negative public effects (negative externalities affecting the social good such as pollution) than those for negative private effects (negative externalities affecting the private good such as health).

Paper [II] examines how sin taxation changes long-term consumer behavior regarding commodities which are deemed harmful for both health and the environment. These include tobacco, alcoholic beverages, sugar and confectionary, household energy, and motor fuel. Specifically, we examine the signaling effect from taxation which is seen if a tax increase leads to a significantly larger change in consumption than a producer price change. The empirical analysis is conducted by a US panel data study, during the period 1988-2012 for the four US census regions, using the Almost Ideal Demand System (AIDS). We find the main result to be that the signaling effect from taxation is significant for tobacco (at the 10% significance level) as well as for electricity and motor fuel (at the 5% significance level).

Paper [III] examines the empirical effect of state and industry responses on consumption of cigarettes and petroleum in the United States from 1998-2012. Upon facing consumption choices, the consumer faces two competing sets of messages, one from the government and another from the industry. The objective of the state is to steer consumption in the right direction due to the harmful effects from consumption and asymmetric information among consumers. This is done mainly via taxation and state media expenditures. The industry, on the other hand, seeks to incentivize the public to ignore or reject state research and signals as well as maximizing net economic returns. This is mainly done via industry media and lobbying expenditures. We find that the main results indicate, for cigarettes, industrial media and lobbying expenditure is statistically significant on consumption. For petroleum, we find that producer prices, state media expenditure, and industrial lobbying expenditure are statistically significant on consumption. While significant results are mainly seen for media and lobbying expenditures, no significant results are seen for taxation.

Keywords: Taxation; legislation; regulation; health; environment; tobacco; alcohol; petroleum; electricity; gas; sugar; consumption; prices; signaling effect; almost ideal demand system; public policy; panel data; media expenditure; lobbying; vector error correction model

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"It is good to have an end to journey toward; but it is the journey that matters, in the end." – Ernest Hemingway

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Erik Brockwell
Umeå University, 2014

This thesis consists of an introduction and three papers:

[I] Brockwell, Erik (2014) "The Signaling Effect of Environmental and Health-Based Taxation and Legislation for Public Policy: An Empirical Analysis", CERE Working Paper #2013-3

[II] Brockwell, Erik (2014) "Signaling through Taxing America's Sin", CERE Working Paper #2014-4

[III] Brockwell, Erik (2014) "The War for Consumers' Minds and Wallets: State vs. Industry Responses on Cigarette and Petroleum Consumption", CERE Working Paper #2014-5

1. Introduction

This thesis contains three self-written papers that address certain key questions on the topic of how consumer behavior is affected by taxation, legislation, public policy, and industry responses. These research questions address the fields of environmental and health economics as well as the political economy. These questions are: (1) does a tax increase of commodities, which produce negative externalities or internalities, lead to a significantly larger change in consumption than a producer price change through a signaling effect? (2) Is the aforementioned signaling effect greater for taxation on commodities that produce negative private internalities as opposed to public externalities? (3) From a panel data study, is the signaling effect significant for a given commodity in the United States? (4) Are legislative and gender interaction effects on taxation significant in any direction? (5) What are the effects of state and industry responses on consumption of cigarettes and petroleum in the United States?

The above questions are the focus of the thesis where we will discuss their importance and the need to undertake research to answer them. Broadly, this thesis considers consumption of tobacco, alcohol, and sugar (primarily affecting consumers' private wellbeing) as well as consumption of residential electricity, natural gas, and petroleum (primarily affecting the public wellbeing). Thus it is quite clear as to the specific importance of these questions with the amount of vast research regarding the negative impacts of these commodities on health care and the environment as well as the way to which the state looks to intervene to solve these negative effects.

2. Taxation and the Signaling Effect

Taxes have long been considered an essential tool and policy lever to change consumption patterns among individuals and society. Commodities like tobacco and alcohol are seen to cause negative health defects. Other commodities such as electricity and petroleum, through pollution, cause negative public effects. Thus there may exist a market failure in sense that the market cost of that harmful good does not fully cover the social cost. By internalizing the external cost with a tax, the individual will adjust its consumption behavior in the desired direction.

Paper [I] and [II] expand upon previous literature through estimating an additional effect from taxation known as the signaling effect. Specifically this is done through investigating whether the effects of a change in consumer prices differ depending on whether the consumer price change is due to a tax change or a change in producer price. If there is a statistically significant difference in the sense that a tax increase leads to a larger change in consumption than a producer price change, this is referred to as the signaling effect from taxation. Here the consumer would cut back on consumption of a commodity more than the effect from the added cost of the tax. This signaling effect would signal properties of that good which enter the consumers' information set.

The notion of signaling expands upon work by previous authors who have supplied arguments questioning the simple mechanism from basic consumer theory. Through signaling, taxation departs from the traditional Pigovian theory as stated by Sandmo (1975). This subject, which has its roots in contract theory and asymmetric information, is covered by Spence (1973, 2002) who states that the consumer may be less informed about the properties of a good than the supplier of that good and the government. The state, which is considered better informed through possession of statistics agencies and specialized research groups, then finds the need to signal properties of the good through taxation to lessen these market failures. However, an issue arises, as pointed out by Truyts (2012), if consumers cannot distinguish the taxed from the untaxed goods this might then impair the informational value of the commodity tax. That is

why, along with the financial disincentive, the government passes along information about its policies to the targets of the regulation (Schneider and Ingram, 1993).

Truyts (2012), furthermore, addresses criticism from certain studies (Ireland, 2001, p. 194) that signaling cannot be observed or accomplished via taxation. Here, Truyts (2012) states, commodities in the same aggregate are assumed similar in essential signaling qualities. Where a commodity without a luxury label or design has just as much of a signal as the most exclusive item, consumers are not easily affected from efforts by the state to signal further properties.

This thesis also brings in discussion on norms within taxation. Leslie *et al.* (1973) defines social norms as *"rules developed by a group that specify how people must, should, may, should not and must not behave in various situations"*. As stated by a collection of authors (Lindbeck *et al.*, 1999; Benabou and Tirole, 2003; Glaeser, 2006), through understanding the justification for and the legitimacy of taxation, public acceptance and tax norm support is more likely. This thesis expands upon these views where tax norm support makes it more likely for the signaling effect to be significant among consumers. If the disutility of deviating from the social norm is high, this would indicate that consumers take into account extra information beyond a simple price effect. Here, for example, a heavy smoker or polluter would risk disutility from health or environmental damage and also may potentially face social disapproval. These are views to which Paper [I] and [II] in the thesis justifies the use of the signaling effect.

Overall, only two papers, to the author's knowledge, have considered the signaling effect empirically: Licari and Meier (2000) and Ghalwash (2007). Licari and Meier (2000) focus on US cigarette consumption from 1955 to 1996 through pooled-time series OLS estimation where the main hypothesis was that, *"when the tax on cigarettes increases, there is an additional signaling effect besides the price increase"*. Licari and Meier's justification for the public being able to perceive signals from taxation is that the negative health effects of smoking are so well known. Media coverage of legislative debates, along with government transmission of research emphasizes these health risks and sends signals of the specific goals and usefulness of tax policy. Analysis was done by modeling addictive phenomena via habit persistence. To do this, a lagged value of the dependent variable is included in a demand model as an independent variable. Overall, results show that the statistically significant signaling effect is seen at 0.15% above a general price increase. Overall, we expand upon Licari and Meier's analysis where no studies have considered the signaling effect of tobacco and related commodities from a European perspective. Through also looking at alcohol (Paper [I] and [II]) as well as sugar and confectionary (Paper [II]), this also provides an extended analysis. Through a stylized model of demand incorporating the prices and consumption for other commodities, we are better able to estimate the specific effect on consumption regarding a change in consumer prices and taxes, compared to Licari and Meier (2000).

Ghalwash (2007) estimates the signaling effect through household demand in Sweden concerning the introduction of, or change in, environmental taxation. The same premise regarding signaling is used here as from Licari and Meier (2000), i.e. that a change in taxation may send a different signal to the consumer compared to one from producer price changes. Referencing Berkhout *et al.* (2004), a difference between the two papers, and one that Paper [I] and [II] employs, is that signaling effect may also differ and change between and when compared to different commodities in a given commodity group. Ghalwash accomplishes this through a system of household demand equations and a three-stage budgeting process[1], using time series data[2] for different commodity groups[3] from 1980 to 2002. The three-stage budgeting process is one that is also employed in Papers [I] and [II] where the first stage assumes that the cost-minimizing household determines how much to spend on leisure consumption, savings, and consumer goods. Second, given a total consumption budget, the household allocates its

[1] Evolving from the two-stage budgeting process for household demand (Gorman, 1959; Berkhout *et al.*, 2004)

[2] Data includes taxation, household expenditures, consumer price, and producer price index levels

[3] Split into four main groups: "Foodstuff", "Transport", "Heating", and "Other goods"

expenditure on commodity groups, i.e. foodstuff, transport, etc. In the third stage, the household allocates expenditure on specific commodities within each group, given its budget for the commodity group.

The main hypothesis put forward by Ghalwash (2007) is that changes in taxation send a different signal than pure price changes. Appropriate demand function estimates are done via the AIDS (Almost Ideal Demand System) model, and subsequent Linear Almost Ideal Demand System (LAIDS) model, first derived by Deaton and Muellbauer (1980). The overall outcome is that changes in environmental taxes had a significant signaling effect on the demand for residential heating where consumers are more sensitive to a tax change than a producer price change. For petrol within transports, the opposite is seen where no significant difference is observed. Furthermore, petrol consumption seems less sensitive to a tax change than from a producer price change.

Papers [I] and [II] deviate upon work by Ghalwash through incorporating a longer timeline for European and American demand and environmental taxes, as well as considering taxes for commodities producing negative public health effects. Paper [I] expands the timeline to cover the period 1970-2012 in order to incorporate the decade as to when research and legislative policies on health and environmental taxes became a major issue. Ghalwash (2007) states that the consistency of the signaling effect may be further affected, due its non-linear nature, where the signaling effect is stronger when taxes are introduced than for subsequent tax changes. Furthermore, by adding more countries to the analysis (Denmark and the United Kingdom), a country-to-country comparison can be done as a point of interest. For Paper [II], a US perspective is given for health and environmental taxes where the signaling effect may have a different outcome. Due to data restrictions regarding consumption data, a shorter timeline is used for this study from 1988-2012.

Given estimates of the parameters in the econometric model in Papers [I] and [II], we can evaluate consumers' sensitivity to a tax change compared to a pure price change, i.e. the price and tax elasticities, as well as the income (or expenditure) elasticities. Here, a significant difference between taxation and producer price would indicate the presence of a statistically significant signaling effect. For the commodities considered, certain articles have found estimated values for the price elasticity of demand to which Papers [I] and [II] compare to for taxation in the conclusion sections. For tobacco, a review from Wilson *et al.* (2012) finds a price elasticity ranging from -0.1 to -1.41 among youths, and 0.1 to -0.45 for adults. This was done through a collection on 84 studies, across 88 publications in various countries, in order to gather the price elasticities of increasing taxes on tobacco products. Paper [II] specifically focuses on American data. Focusing on the US, Wasserman *et al.* (1991) and Chaloupka *et al.* (2002) estimate since 1970 that results have varied greatly from -0.25 to -1.3.

Concerning alcohol, a study by Wagenaar *et al.* (2009) is given where they conduct a review across 1,033 estimates from 112 different studies. Here they find the mean price elasticity ranging between -0.46 (beer) and -0.80 (spirits). Wagenaar *et al.* (2009) finds overall that there is a large variation between the results. Paper [II] expands upon commodities that affect the public health of the consumer by including sugar and confectionary into the analysis. Andreyeva *et al.* (2010), to gather the price elasticity of demand, conducted a review across 160 studies for major food categories. Here, a mean long-run price elasticity of -0.34 is found for sugar and confectionary.

For residential electricity, through a comprehensive literature review, Espey and Espey (2004) give short-run and long-run price elasticities for US residential electricity to be -0.35 and -0.85, respectively. For residential natural gas, Dahl (1993) states that from a review across many studies that price elasticity is around -0.27. However these results from Dahl (1993) have been shown to be quite varied where a clear consensus is not clearly seen. We also see that from these two studies that for natural gas is often more price inelastic than electricity. Finally, considering petroleum (or gasoline) demand, Brons *et al.* (2008), through a dataset of 312 elasticity

observations for gasoline demand, finds that the price elasticity of demand is quite inelastic for short-run and long-run elasticities of -0.36 and -0.81, respectively. An interesting note from the study by Brons *et al.* (2008) is that a pricing policy based only on gasoline taxes may not be a very effective instrument to decrease the demand for gasoline. None of the other studies considered have come to such a conclusion, and so it is a hypothesis that this thesis will examine.

Paper [III] does not directly consider taxation in terms of the signaling effect, but rather taxation on whole as a policy tool along with other state media expenditure against industry responses (industrial media and lobbying expenditure)[4]. The same thinking, as with the signaling effect, is used regarding social norms. Along with the price effect of taxation, the message of taxation that consumption of tobacco and petroleum produces negative effects is reinforced via changes in social norms. Social norms are changed through generating public support for control policies (e.g. tax initiatives and restrictions) as well as changing attitudes and beliefs towards consumption. As stated by Jacobson *et al.* (1997), the government can validate or justify regulating a legal good, sustain decreasing consumption, and counter industry responses. Without these efforts, taxation may not have such a large effect where political backlash may result without generating public support. Licari and Meier (2000) and Friend and Levy (2002) state this is done through paid-for state media campaigns and research where the better informed government, through possession of statistics agencies along with specialized research groups, disseminates this information through mutual communication streams[5].

3. Legislation

Papers [I] and [II] expand beyond considering purely the signaling effect from taxation through analyzing the effects of legislative introductions through specific laws and policies. As motivated by Licari and Meier (2000), realistically taxation cannot effectively transmit signals in isolation. The government has a key function to disseminate this through mutual communication streams (through, e.g. legislation, public information campaigns, etc.) to persuade the consumer to alter beliefs. Here, it is believed that the price/tax effect may be reinforced or crowded out if a change in taxation is combined with a non-price signal, through changes in legislation, such as an informational campaign. This deviates from the assertion by Ghalwash (2007) that the effects of legislation are implicitly included in the tax function.

To model legislative introductions, Licari and Meier (2000) adds an interaction term as a dummy variable that takes a value of 0 prior to 1966, 1 from 1966 to 1996, and 2 from 1971 to 1996 to take into account introductions of warning labels and advertising bans. These two events are deemed "key events" in government policy. Legislation is hypothesized to, firstly, have a direct impact on smoking to quit or reduce consumption. Secondly, legislation should have an indirect impact on efficacy of tax increases on smoking. These reasons for the second hypothesis is that consumers have other reasons besides economic ones to reduce consumption and thus may be less influenced by economic factors; secondly, remaining smokers may be more resistant to incentives to quit and thus are more price inelastic.

Paper [I] and [II] further expands upon previous literature as it is assumed that legislation directly interacts with the ability of taxation according to how households perceive changes in the tax level. These changes in legislation are included within the aforementioned final stage of the household budgeting process. From this it is shown that each legislative increase is collected, added, and reflected within the consumption behavior of the household as an index of regulatory pressure. It is also assumed that coefficients for legislation are not equal across time

4 Media and lobbying expenditure is defined in Section 4.

5 Such communication streams include public service announcements through various forms of media, discussions regarding research on consumption, and announced descriptions of legislative introductions.

but instead is an individual effect from each law passed. Whilst logically it may be the case that the effects of legislation on consumer behavior may decay over time as it loses its impact or relevance, for simplicity, we assume long term memory across households having zero decay over time concerning legislative effects.

Another addition to the study is an expanded list of legislative introductions where by research from Swedish, Danish, British, European Union (EU), and US law databases[6], there has been multiple legislative introductions and revisions to previous commodity legislation including media restrictions, warning and educational labels, and subsidies to households to list a few. An advantage of Paper [I] considering numerous countries is that for certain commodities, some governments relied mostly on industry self-regulation. For the US, in Paper [II], the list of legislative introductions also includes executive orders signed by the president. Each legislative introduction, in Paper [I] and [II] is included once passed and signed as law.

4. Media and Lobbying Expenditure

Before explaining the overview of media and lobbying expenditure, it is important to set up the premise as to why this is important. This is the main topic presented in Paper [III] where we consider consumption of harmful commodities which create negative health and environmental effects; in this case, these commodities are tobacco and petroleum. When the consumer makes their choices, they are often faced with two competing sets of messages, one from the government and another from the industry producing the harmful commodity. The objective of the government is to steer consumption in the right direction, i.e. to reduce consumption of these commodities, to minimize the cost to the consumer and the public.

The rationale for this is that, as stated by Mathewson (1972) and Hu *et al.* (1995a), consumption of commodities that are bad for the individual or for the public is irrational and may be based on imperfect information. This is as consumers hold only partial knowledge on the characteristics or consequences of goods consumption as well as the state of the world and nature. Thus there is a case, as with taxation, to correct these market failures of asymmetric information and negative internalities/externalities. Through similar logic as with legislation, to reinforce the reasons for taxation, and to potentially enhance the effect from taxation, the better informed government uses media expenditure in order to validate or justify regulating a legal good and educate the public as to the effects from consumption (Jacobson *et al.*, 1997; Licari and Meier, 2000; Friend and Levy, 2002). Such media expenditure is communicated through various media outlets (e.g. print and TV advertisements), government broadcasts, and via educational material.

Considering tobacco state media expenditure, many authors claim that well-funded and implemented mass media campaigns, joined with comprehensive control programs are associated with sustained reduced consumption (Friend and Levy, 2002; CDC, 2004; Ibrahim and Glantz, 2007). However, despite the evidence that state media expenditure is effective, tobacco control media campaigns have proven difficult to sustain due to industrial counter-advertisements and a lack of state funding.

State media expenditure on petroleum, however, is conducted slightly differently than that for tobacco. Whereas tobacco media expenditure is done in order to get consumers to quit smoking, media communication on the effects of petroleum consumption does not ask consumers to simply stop buying fuel or stop driving. Instead the goal is to show the long term effects from pollution and climate change from consuming great amounts of fuel. As stated by Colman (2012), the government seeks to counter messages by the oil and gas industry who aim to downplay the severity of climate change. This being where the oil industry who has spent

[6] Law databases used are, for: Sweden (http://www.notisum.se), Denmark (https://www.retsinformation.dk/), UK (http://www.legislation.gov.uk/), EU (http://ec.europa.eu/health/tobacco/law/index_en.htm), and the US (THOMAS database from the Library of Congress).

millions of dollars on ad campaigns belittling government research and attacking U.S. energy policies as being against economic growth and 'anti-jobs'. The need for such communication is clear, where unlike smoking where its cancerous effects are clear, only 63% of Americans believe climate change is happening while the rest are unsure or deny its existence (Leiserowitz *et al.*, 2013). All this is despite a large consensus from the scientific community that climate change poses serious risks to human societies and ecosystems, which have already begun to happen[7] (Hmielowski *et al.*, 2013).

On the other hand, the objective of the industry is to maximize profits by encouraging consumers to consume more. This is done through messages to incentivize the public to ignore or reject state research and signals through various motivations, e.g. through arguing against research, political support, and making the product seem more attractive or enticing. This is especially true if messages sent by the state are uncomfortable to believe or where there exists skepticism.

Considering industry media advertising, there are certain key aims, as stated by Warner (1985) and Van den Hove *et al.* (2002), for the industry. Firstly, the industry seeks to have consumers focus on the external attributes of consumption. For smoking, this is to divert attention from health concerns to promote attributes such as flavor, satisfaction, sex appeal, and individuality. Secondly, given scientific evidence regarding the health effects of smoking and the environmental damage from petroleum consumption, the industry seeks to label such research as "junk science" or to say such reactions are exaggerated. Brownell and Warner (2009) stated, for tobacco, this is commonly done denying the addictive and destructive nature of smoking. For petroleum, discrediting scientific evidence of climate change has been an important aim due to the aforementioned increase in scientific reports regarding the severity of climate change. Thirdly, the industry may try and promote themselves better through public relations and image-restoration. The tobacco industry, stating that they are concerned about the public health may instead promote "less-hazardous products". For the petroleum industry this has been a major aim since the 2010 BP oil spill in the Gulf of Mexico where massive fines were levied and sweeping regulation was called to prevent another incident. Lastly, as stated by Sutter (2002), advertising from industries also seeks to label state messages and actions as anti-business or holding political bias. The industry would try and increase support for the domestic economies and feed opposition to alleged "government interference" and to defend the "free-market system".

Few studies have directly considered the effects on consumption of state vs. industry media expenditure empirically. Motivation for considering media expenditures in Paper [III] was through a study by Hu *et al.* (1995a) who studied California's antismoking media campaigns against industry media campaigns on cigarette consumption from 1980 to 1993. The authors also took into account tax, measured per pack of cigarettes; consumption was given in quarterly values as well. California's antismoking media campaign is measured in terms of media placement expenditures by the Tobacco Control Section in the California Department of Human Services. On the other side, industrial media expenditure is obtained through quantifying total pages of cigarette advertising in Life magazine distributed in California.

To gather the effects on consumption, Hu *et al.* (1995a) employed a time series model with explanatory variables including a time trend, quarterly dummy variables, California's state tax, the federal tax rate, retail price (minus state tax) as well as state and industrial media variables. Overall, results show that the state media campaign has a statistically significant negative effect on cigarette consumption and the industry media campaign has a statistically significant positive effect on consumption. Both the federal and state tax rate as well as the time trend show statistically significant and negative impacts on cigarette consumption as well.

[7] As reported by the IPCC (2014), such examples include: 1) Changing precipitation rates and melting of the polar regions have led to sea level rises as well as changes of the quality and quantity of water resources; 2) Many terrestrial, freshwater, and marine species have shifted their geographic ranges, migration patterns, abundances, and species interactions; 3) Net crop yields have been negatively impacted; and 4) Pollution levels have caused a decrease in the air quality in many urban locations.

Paper [III] expands upon Hu *et al.* (1995a) through not only examining the effects of state and industry action on consumption of cigarettes (tobacco) but also to consider petroleum where there has been no such study to the author's knowledge. We also do not look at the state level, but instead the federal level where there has been no other studies covering this to the author's knowledge. As with Hu *et al.* (1995a), Paper [III] includes taxation as part of the government's response to consumption along with media expenditures. However, for the industrial counterbalancing response, we deviate from Hu *et al.* (1995a) through also incorporating implicit communication to the consumer in the form of lobbying. This is due to a subsequent paper by Hu *et al.* (1995b) as well as recommendations from Begay *et al.* (1993) that for the example of California, lobbying efforts may have been cost-effective for the tobacco industry compared to countering the state's media campaign. This would be an interesting point to explore if the same effect is found on the federal level and also through lobbying by petroleum action groups.

Another of the main industrial reactions to the state is through lobbying. This serves as a form of indirect communication where the industry would work through policymakers to persuade them on what is good policy and what statements should be given. As discussed by certain authors (Brock and Magee, 1978; Kollman, 1998), lobbying is defined as activities by special interests and industries to argue for specific legislation in the government. Here, such methods are done through transparent contributions to a politician or political committee. The public is hence made aware of these messages through rules requiring extensive disclosure and through politicians' statements and decisions (e.g. campaign speeches, statements on laws passes/defeated, and organized messages to the public).

Brock and Magee (1978) and Kollman (1998) refer to lobbying as a traditional rent seeking method where a straightforward *quid-pro-quo* exchange of money is given for political decisions. If the interests of the policymaker and the industry conflict, a strictly positive contribution is required to enhance the credibility of industry reports on the reasons they require support (Lohmann, 1995). A key dynamic effect of industrial lobbying is that such expenditures can be a long-term investment which may not bear fruit right away (Kang, 2011).

A great deal of literature has debated the effectiveness of lobbying for the tobacco and petroleum lobbies. The tobacco lobby has seen a great number of challenges where it is argued that the power of the tobacco industry to sway politicians has decreased over the years where a growing number of people view tobacco lobbying efforts very negatively and as public health programs have become more successful. Furthermore, literature on this subject has stated that in spite of their contributions, declining political persuasion is due to the unfavorable association with the lobby and the social costs of increased consumption on negative externality producing commodities (Brock and Magee, 1978; Givel and Glantz, 2001; Kolk and Levy, 2001).

For petroleum lobbying, many authors (Kolk and Levy, 2001; Gelbspan, 2004; Kolk and Pinkse, 2007) have said unlike for the tobacco lobby, the effectiveness of petroleum lobbying has increased over the years in persuading the politicians and the public alike through claims that climate change science is exaggerated and that green policies will only hurt the economy. Thus we have seen a declining number of passed legislation and new taxes while high levels of consumption have persisted. From a study of lobbying in the energy sector, Kang (2011) states that environmental regulations also directly impacts the competitive advantage based on the current level of cleaner production technologies. Thus many companies in the energy industry seek to lobby the government. Here, the petroleum lobby forms the largest lobbyist spending group in Washington.

Overall, the public may accept lobbying as benefiting the policymakers' work and a potential help in avoiding bureaucratic errors. However, lobbying may instead have the opposite effect than intended due to the negative perception held by the public where these forms of contributions may be seen as another form of manipulation, corruption, or bribery. However, it is not easy to predict the impacts of lobbying as it depends on how the politician reacts to

lobbying efforts. As quoted by Kollman (1998), "*sometimes these campaigns have their effects – just as rain sometimes follows the rainmakers' dance*".

5. Data Considerations

In this thesis, a wide variety of data is used from many sources. A core contribution of each paper is that the datasets used are unique to the study. Paper [I] uses publicly available data from Sweden, Denmark, and the United Kingdom. Data considered include indices on prices (consumer and producer prices), household consumer expenditure, and population figures. As these indices have a different base year depending on the timeline of the dataset used, these indices are rebased (2005 = 100) in order to have a consistent timeline. Data from Sweden is collected from Statistiska Centralbryån (Statistics Sweden, SCB); data from Denmark is collected from Danmarks Statistik (Statistics Denmark); and data for the United Kingdom is collected from the Office of National Statistics (ONS). Consumption data is given per capita to account for changes in the population where population figures are also provided through these statistics agencies.

Furthermore, to consider the aforementioned effects of legislation, individual legislative introductions are collected from country law databases. This is done through searching domestic and EU-wide laws which specifically affect the population as a whole as opposed to a specific section of the population (e.g. laws targeting under-21 students). The legislative introductions are referred in Paper [1] as "major legislative introductions". Furthermore, this study ignores "voluntary agreements" (or self-regulation[8]) which are considered non-binding agreements between the state and the commodity producing industry. These are ignored as the industry may circumvent these agreements as no penalty is imposed for violating these agreements.

We can see from the legislative introductions recorded, that all three countries have varying levels of legislation introduced where some prefer relying on voluntary agreements or self-regulation. For example, we see that tobacco legislation has been quite extensive across all three countries. Alcohol legislation, on the other hand, is generally favored in Sweden, where Denmark and the UK have a system preferring self-regulation. For household energy and petrol, for all three countries, legislative introductions are more often imposed on the suppliers and producers rather than the consumers (OECD, 2008). Swedish legislation data is collected via Notisum AB (Swedish Legislation Archive, www.notisum.se); Danish legislation data is collected via Retsinformation (Danish Legal Information Archive, www.retsinformation.dk); legislation data for the United Kingdom is collected via The National Archives (www.legislation.gov.uk); and EU-wide legislation data collected via Europa[9].

For Paper [II], a panel data study is conducted for the United States by region of residence across the four census regions (East, Midwest, South, and West). To accomplish this, specific data for the Consumer Price Index (CPI) and the Consumer Expenditure Survey is gathered across these regions. Here, the CPI is measured through monthly reported indices representing changes in prices of goods and services purchased for consumption, user fees (such as for utilities), as well as sales and excise taxes.

Data for producer prices is collected via the Producer Price Index (PPI). These indices are reported on a national level as they are constant throughout each census (or panel) region. These PPI values measure the average change over time in the selling prices received by domestic producers for their output, i.e. the first commercial transaction for many products and services.

8 Self-regulation is defined as control of policies or restrictions exercised independently of government supervision, laws, or the like.

9 Europa - http://europa.eu/legislation_summaries/consumers/index_en.htm

The Consumer Expenditure Survey consists of two national surveys: the Quarterly Interview Survey and Diary Survey. This is done to collect information on household and families' buying habits (expenditures) as well as income and household characteristics. Unlike the CPI datasets, Consumer Expenditure Survey is reported annually. This means that we are unable to conduct a quarterly study across the timeline (1988-2012). The timeline goes back as far as 1988 due to the Consumer Expenditure Survey being incomplete before this year. Furthermore, this panel data study is not conducted by a state-by-state basis due to unavailability of Consumer Expenditure Survey data. To calculate CPI values yearly, we take the average across the year to give yearly values. Another unique aim of Paper [II] is to consider if there has been any effects from changes in the gender share over time. This being as through the U.S. Consumer Expenditure Survey[10], the sampling of men and women has changed over time quite dramatically. For example, on average across the four regions considered, in 1988 within the sample there were 68.75% men and 31.25% women within the survey. In 2012 this changed to 46.75% men and 53.25% women. This shows the sample has potentially been biased towards men[11]. Data on gender shares is also collected from the Consumer Expenditure Survey given in percentages across each year.

Data for the Consumer Price Index, Producer Price Index, and the Consumer Expenditure Survey are collected via the Bureau of Labor Statistics (BLS). Data from the Consumer Expenditure Survey is given per capita to account for changes in the population where population figures are also provided via the U.S. Census Bureau.

To gather the interaction effects on taxation from legislative introductions, Paper [II] only considers federal legislation (not state-specific as to fit with our national analysis) that affects the household's consumption decision directly covering the population as a whole, not a select group (e.g. children, veterans, etc.). We do not consider state-specific legislation here as, for example, a state law passed on tobacco in Massachusetts would not have an effect in New York or any other state in the East census region. Furthermore, we do not consider legislation that has not been signed by the president during the stage in the legislative process. This includes legislation passed by only the House and Senate as each state is not under any obligation to implement these laws. Legislation data is collected through the THOMAS database from the Library of Congress, through searching the bill summary and status[12], the National Archives database of Executive Orders signed by the President[13], and the U.S. Food and Drug Administration (FDA) "Guidance, Compliance, and Regulatory Information"[14].

Lastly, for Paper [III], this paper uses readily available quarterly time series data covering the years 1998-2012 from various data sources for the United States. An advantage of conducting analysis for the United States is that certain data on lobbying and media expenditures is easier to obtain for the United States than for Europe. Analysis for this paper is conducted on the national (federal) level as much of the data is incomplete or unobtainable on the state-by-state level. Lastly, we begin from the year 1998 as this is the first year that data on lobbying is available on the public record.

Data on consumption refers, in Paper [III], to that for cigarettes and petroleum. Here, cigarette consumption is calculated as cigarettes consumed per capita whilst petroleum products are consumed in barrels (thousands) per capita. These represent real values consumed and not indices values. An advantage of this is that we may avoid a possible 'index-number problem' which refers to the difficulty of combining relative changes in the prices and quantities of various commodities into a single measure of the relative change of the overall price or quantity

[10] The Consumer Expenditure Survey is detailed in Chapter 3.2 for the description of data.

[11] See the description of Paper [II] for more details.

[12] THOMAS database – Search Bill Summary and Status: http://thomas.loc.gov/home/LegislativeData.php?n=BSS

[13] National Archives Executive Orders: http://www.archives.gov/federal-register/executive-orders/

[14] FDA Guidance, Compliance and Regulatory Information: http://www.fda.gov/drugs/guidancecomplianceregulatoryinformation/default.htm

level (ILO *et al.*, 2004). We count cigarettes instead of tobacco as a whole as other forms of tobacco units consumed (e.g. snuff, chewing tobacco, etc.) are not readily available to the author's knowledge. As other forms of tobacco form a small fraction of the total tobacco consumption, this should not lead to any severe estimation errors. Petroleum consumption refers specifically to distillate fuel oil and liquefied petroleum gases. Consumption data is collected via the Alcohol and Tobacco Tax and Trade Bureau (within the Department of the Treasury) and the U.S. Department of US Energy Information Administration (EIA) for cigarettes and petroleum, respectively.

Quarterly data for producer prices are given for cigarettes and petroleum excluding federal taxes in current prices. As with Paper [II], producer price data is given as indices taken at the national or federal level where producer prices do not vary state by state. This data is obtained from the United States Department of Labor Bureau of Labor Statistics (BLS). For quarterly taxation values we consider excise taxation cigarettes and petroleum, which is defined as indirect taxes on the use or consumption on listed items. These excise taxes are taken on the federal level and come as part of the overall consumer price that the consumer pays for a given commodity. For tobacco, these taxes are measured in cents per pack of 20 cigarettes and are obtained quarterly from the average across all fifty states. The same principle is applied for petroleum but measured in cents per gallon. Excise tax data is obtained via the Department of Health and Human Services Centers for Disease Control and Prevention (CDC) and the U.S. Department of Transportation Federal Highway Administration (FHWA) for cigarettes and petroleum, respectively.

GDP measures, controlling for income are also included to detail how the income of a country may affect consumption. Data for GDP levels (measures in billions US$) was provided by the U.S. Bureau of Economic Analysis.

A key variable in the analysis for Paper [III] is state advertising spending on tobacco and petroleum. However, two separate measures are given between the two. Tobacco industry state advertising spending is provided annually by the Campaign for Tobacco-Free Kids database on state spending vs. tobacco industry marketing. This provides quarterly expenditure by the state for specific advertising and media outreach regarding the harmful effects of cigarettes. However, state ad spending concerning petroleum operates in a different nature than that of tobacco where advertisements do not directly ask consumers to simply stop driving or to stop buying fuel. However, research campaigns showing negative effects on the public good are communicated through various media outlets, government broadcasts, and via educational material. To this point, we use data provided for the U.S. Global Climate Change Research Program (USGCRP) on research and transmission of results through various outlets as a measure of the state response. Data for the financial reports of the U.S. Global Climate Change Research Program[15] are released annually. As monetary variables it is appropriate to deflate these variables based on the current level of consumer prices and thus we use the quarterly U.S. Consumer Price Index (CPI) (1997 = 100) given by the Bureau of Labor Statistics (BLS). This is to take into account the effects of inflation over the timeline.

Considering industry media expenditures, tobacco industry ad spending is provided annually by the Campaign for Tobacco-Free Kids database on state spending vs. tobacco industry marketing. This refers to specific ad spending by the industry to promote increased consumption amongst consumers, as detailed in Section 3. Comprehensive and consistent quarterly data on petroleum industry media expenditures is, however, particularly difficult to obtain and not readily available. Thus, a measure for media expenditures is done via proxy. As suggested by the Union for Concerned Scientists, on average the petroleum industry spends 8% of its total profits on advertising and marketing. Using this benchmark, may not be a fully accurate representation of advertising spending but holds as an approximate figure for this study. Data on profits is given annually by the IEA (International Energy Agency). As with state media expenditures, these

[15] U.S. Global Climate Change Research Program - http://www.globalchange.gov/home

datasets are deflated based on the current level of consumer prices from the quarterly U.S. Consumer Price Index (CPI) (1997 = 100) given by the BLS.

Lastly, quarterly data on lobbying is collected via The Center for Responsive Politics from 1998 to present date. To ensure accuracy, these values are checked against records provided by the U.S. Federal Commission. Due to data restrictions, lobbying data from 1998 to 2007 was reported on a mid-year and year-end basis before quarterly reports were published. From 2007 onwards, data is given on a quarterly basis. Here, this data refers to lobbying expenditure from a specific company, lobbying firm, or individual lobbyist. These amounts are filed with the Secretary of the Senate's Office of Public Records (SOPR) where lobbyists are required to provide a 'good-faith' estimate rounded to the nearest $10,000 in each quarter.

6. Summary of the Papers

Paper [I]: The Signaling Effect of Environmental and Health-Based Taxation and Legislation for Public Policy: An Empirical Analysis

This paper examines how taxes affect consumption behavior of tobacco and alcohol[16], which are detrimental for public health, as well as electricity, natural gas, and petroleum which are detrimental for the environment. Specifically, this paper investigates whether the change in consumer prices differs depending on whether the price change is due to a tax change or a change in producer price. A statistically significant difference in the sense that a tax increase leads to a larger change in consumption than a producer price change is referred to as the signaling effect. Additionally, this article estimates how legislative introductions may interact with taxes. For the empirical analysis, this article uses aggregated time series data for Sweden, Denmark, and the United Kingdom, covering the period 1970-2009.

The logic behind the signaling effect is that the consumer may be less informed about the properties of a good than the supplier of that good and the government. The regulator or policymaker, who is considered better informed through possession of statistics agencies along with specialized research groups, may deem consumption to be too high or low from both the individual and social point of view (Spence 1973, 2002). As asymmetric information presents a market failure, the government is validated to correct this.

However, realistically taxation cannot effectively transmit signals in isolation. The government has a key function to disseminate this through mutual communication streams to persuade the consumer to alter beliefs. The price and/or tax may have a signaling effect, and therefore such an effect may be reinforced if a change in taxation is combined with a non-price signal, for example changes in legislation such as an informational campaign.

To empirically model consumer behavior, this paper implicitly adapts a three-stage budgeting model as recommended by Ghalwash (2007). Here, the first stage assumes that the cost-minimizing household determines how much to spend on leisure consumption, savings and consumer goods. Second, given a total budget, the household allocates its total expenditure for commodity groups, i.e. foodstuff, transport, etc. Third, the household allocates expenditure on specific commodities within each group, given its budget for the commodity group.

The econometric method used expands upon the basic form of the AIDS (Almost Ideal Demand System) model first developed by Deaton and Muellbauer (1980b) and used, among others, by Ghalwash (2007). Through partitioning producer prices and taxation from the overall consumer price, the parameters gathered help separate the effects between these prices. Estimates are gathered both on the commodity group level (e.g. Foodstuff) and for the individual commodity

[16] As well as alcoholic beverages in aggregate, analysis is also done splitting alcohol up for Spirits and Wine and Beer

level, which represents the second and third stage of the three-stage budgeting model, respectively.

Considering the third stage, possible effects from legislation and information is introduced via a set of dummy variables representing major legislative reforms or information campaigns upon the point of implementation. These dummies are assumed as interacting with the tax variable as legislation and information may reinforce the tax effect. This is done via interaction terms that are included with the parameter for taxation.

The results show that the "Foodstuff" and "Household energy and utilities" commodity groups have a significant signaling effect both at the 1% level. For individual commodities, we see a significant signaling effect from taxation for Electricity at the 5% significance level. For Denmark, as with Sweden, we have a significant signaling effect through only Electricity taxation but at the 1% significance level. Finally for the United Kingdom, both Electricity and Petrol possess a statistically significant signaling effect at the 1% and 5% significance level, respectively.

Paper [II]: Signaling Through Taxing America's Sin: A Panel Data Study

This paper conducts a panel data study to examine how 'sin taxation', via the signaling effect, changes long-term consumer behavior regarding commodities which are deemed harmful for both health and the environment. Specifically, we use US panel data from 1988-2012 for the four census regions: 1) Northwest; 2) Midwest; 3) South; and 4) West. Commodities considered here are Tobacco, Alcoholic Beverages, Sugar and Confectionary, Electricity, Utility Natural Gas, and Motor Fuel (Petroleum).

The signaling effect refers to when taxation leads to a larger change in consumption than the producer price due to an added informational effect regarding the properties of a given commodity on top of the price effect. Here, taxation signals to the consumer the properties of the good consumed on how consumption affects negatively the public good via, e.g. pollution, or the private good via, e.g. health effects. The government seeks to disseminate this through mutual communication streams through, e.g. legislation, public information campaigns, etc., to persuade the consumer to alter beliefs (Licari and Meier, 2000).

Also included in the model is the effect of changes in gender shares within the U.S. Consumer Expenditure Survey where the sampling of men and women has changed over time quite dramatically. This shift in gender shares over time shows there may be a selection problem in the Consumer Expenditure Survey where the sample may not be representative of the population.

For use in the econometric model, this paper adopts, as in Paper I, the three-stage budgeting model assuming in the first stage, the cost-minimizing household determines how much to spend in total. Second, given a total budget for consumer goods, the household allocates its expenditure for commodity groups, i.e. foodstuff, household energy, etc. Third, the household allocates expenditure on specific commodities within each group.

The model employed expands a fixed effects panel data approach upon the basic form of the AIDS (Almost Ideal Demand System) model first developed by Deaton and Muellbauer (1980), and expanded by Ghalwash (2007). To estimate the individual parameters within the total consumer price, commodity prices are partitioned into a producer price component and a tax component. To account for the aforementioned gender share changes, the model is appended with an interaction between gender shares and the tax effect. To model the effects of legislative introductions, this is done through a set of dummy variables, representing major legislative reforms or information campaigns upon the point of implementation. Interaction terms are added to the econometric model which also comes as part of the tax effect.

Overall we see from the results that, for the "Foodstuff" commodity group, there exists a significant signaling effect from tobacco taxation at the 10% level. No statistically significant effect, however, is observed for Alcoholic Beverages or Sugar and Confectionary. Considering the "Fuels and Related Products and Power" commodity group, we find a significant signaling effect from taxation for electricity and motor fuel at the 5% level. However, no such effect is observed for Natural Gas.

Considering legislation, for the "Foodstuff" commodity group, we find two significant interaction effects from 1990 referring to the "Nutrition Labeling and Education Act" and in 2006 referring to the FDA revision for labelling of trans-fat and fatty acid amounts. Considering the "Fuels and Related Products and Power" commodity group, we find no significant interaction effects from legislation for any commodity. Considering the interaction effects from gender shares, from the "Foodstuff" and "Fuels and Related Products and Power" commodity groups, no statistically significant interaction effects were found. One possible interpretation to this is that consumption behavior does not differ significantly between men and women.

Paper [III]: The War for Consumers' Minds and Wallets: State vs. Industry Responses on Cigarette and Petroleum Consumption

The objective of this paper is to examine the effect of state and industry responses, or measures, on consumption of Tobacco (cigarettes) and Petroleum in the United States. Specifically, the government seeks to discourage consumption of these harmful goods through taxation and state media expenditures. We then examine the industry's response, which seeks to increase consumption, via industry media and lobbying expenditures. Through time-series expenditure data, this article will conduct analysis from the years 1998 to 2012.

Upon facing consumption choices, the consumer faces two competing sets of messages, one from the government and another from the industry producing the harmful commodity. Given the well-documented effects of cigarette and petroleum fuel consumption, the objective of the government is to steer consumption in the right direction to minimize cost to the consumer and the public.

Consumption of commodities which produce these negative effects are deemed irrational where it is hypothesized that the decision to consume, knowing these effects, may be based on imperfect information as consumers hold only partial knowledge on the characteristics or consequences of commodity consumption (Mathewson, 1972; Hu *et al.*, 1995a). There is then a case for the government to intervene to correct these market failures of asymmetric information and negative internalities/externalities. This is mainly done via taxation and media expenditures.

On the other hand, the industry's objective is to maximize net economic returns, which in turn motivates marketing and communication campaigns as well as lobbying expenditures (working through the politicians). The main aim of industrial communication is to incentivize the public to ignore or reject state research and signals through various motivations. In this paper, these aims are done via industrial media and lobbying expenditures.

The model employed is a Vector Error Correction Model (VECM), where short-run coefficients are given across each variable and for each variable. However, to get long term coefficients for consumption, which is set as the dependent variable, separate equations form the variables in the system of equations are normalized on consumption to get the cointegrating vector. This follows tests for unit roots for the time series variables and determination the number of cointegrating equations using the Johansen test for cointegration.

In our results, we see for cigarettes a statistically significant result is seen for industrial media expenditure (IM) and industrial lobbying expenditure (LOB), both at the 1% level. A unique result of this study is that industrial media expenditure is not of the expected sign. Here an

increase in industrial media expenditure is associated with a fall in consumption. Lobbying is, on the other hand, of the expected sign where an increase in lobbying expenditure is associated with a rise in consumption. No statistically significant result is observed, however, for producer price, taxation, government media expenditure, and income.

For petroleum, we see that producer price, government media expenditure, and industrial lobbying expenditure are significant at the 1% significance level. Producer prices (P) is also significant but at the 10% level. Here, all coefficient values seem to be of expected sign where an increase in producer prices and government media expenditure is associated with a fall in petroleum consumption. However, an increase in industrial lobbying expenditure would likely be followed by an increase in consumption.

7. Policy Implications and Future Research

Considering taxation in Sweden, Denmark, and the United Kingdom (as seen in Paper I), a significant signaling effect is seen for electricity (in all three countries) and petroleum (in the UK). However, no significant results are seen for tobacco, alcoholic beverages, or natural gas. From the results given we can conclude that environmental taxes seem more effective than that for health taxation (for tobacco and alcoholic beverages) regarding the signaling effect. Specifically this indicates that environmental taxation seems more effective in signaling the properties and negative impacts of electricity and petroleum consumption. Here, consumers may be much more aware of the negative effects from consumption, which then means that additional 'signals' will have very few additional effects. Direct policy implications may be that the policymakers be advised to maintain, or even increase, the level of taxation on such products.

Although no statistically significant outcome is seen for health taxation on tobacco and alcoholic beverages, this does not mean that policymakers should abandon or decrease current taxation. Taxation is still effective in the sense that it still works to lower consumption via the normal 'price effect'. Taxation in this case still holds a signaling effect at least to a small degree and is furthermore a key policy lever to decrease consumption and provide funding to the state and further legislation. Direct policy implications may be to focus and expand upon current legislation on these products as well as implementing additional legislation introductions.

However from the US perspective (as seen in Paper [II]), we see a statistically significant signaling effect for tobacco, electricity, and motor fuel. Here, this signals to the policymaker that taxation is an effective method to signal the negative properties from consumption, e.g. health defects or pollution, to the consumer and to incentivize reduced consumption. Policymakers here would be advised to consider taxation as the most useful policy tool for signaling informational properties of the commodity and to reduce consumption. Furthermore, for electricity and petrol, in the face of political resistance from the public regarding energy and fuel prices, this signals a good result that the public may be more receptive to a price increase than previously thought.

Considering consumption of alcoholic beverages, sugar and confectionary, and natural gas, no significant results are seen for the signaling effect. From these results, policymakers would be ill advised to simply consider taxation as an ineffective policy tool. Simply, the signaling effect is not as large as for tobacco, electricity, and motor fuel in significant terms but still is a vital policy lever for reducing consumption via the price effect. As with the European perspective, the US government may look to increase and expand upon existing legislation or look to introduce new more comprehensive forms of legislative introductions.

For legislation of these harmful commodities, we see a wide range of results as to which legislative introductions have been effective in interacting with taxation to reduce consumption.

For tobacco, such successful policies include smoking bans in public places as well, restrictions on advertising for tobacco products, requirements of health warning labels, and increased penalties of sales to underage persons. For alcohol, statistically significant legislation includes the labeling of a beverage's alcoholic strength, tighter regulation of media advertising, and educational messages warning consumers on the consequences of excessive consumption. However, these significant results are only seen in Sweden where no significant results are seen (for alcohol) in Denmark, UK, or the USA. For these countries, policymakers may be advised to revise existing legislation or consider new effective legislation to implement. For the US (as seen in Paper [II]), statistically significant results are seen for sugar and confectionary legislation. Such successful laws that policymakers would be advised to continue, and even expand upon, include nutrition labelling and education regarding the impact of consumption as well as the FDA revision for labelling of trans-fat and fatty acid amounts.

For household energy (electricity and natural gas), examples of successful (statistically significant) legislative introductions, which the policymaker would be advised to continue and expand upon, include the labelling of appliances and light bulbs[17] as well as price transparency from household energy used. For motor fuel (petrol), successful legislative introductions include the requirement of car dealers to include in each vehicle and petrol selling location the fuel consumption and CO2 emission figures of that vehicle as well as educational material on how to minimize fuel consumption and the impact of CO_2 emissions. These results are consistent for Sweden, Denmark, the United Kingdom, and the United States (Papers [I] and [II]), with statistically significant results in the negative direction, implying to the policymaker that such legislation has been useful in reinforcing the tax effect to reduce consumption. However, for motor fuel, no significant legislative results are seen for the US (Paper [II]).

From the results given regarding state and industry actions to affect consumption of tobacco and petroleum (Paper [III]), we are hence able to see clear policy recommendations for the state in order to counter the tobacco and petroleum industries for incentivizing sustained decreases in consumption. For tobacco and petroleum, with no statistically significant effects, taxation has not been as effective, as hoped for, as a policy lever to affect consumption decisions of the consumer. Whilst we still achieve a negative effect from price and tax effects in our model for petroleum, a slight positive result is achieved on cigarette consumption. This may indicate that the consumers may be more responsive to price changes on petroleum products. Overall, these results may indicate to us that taxation may not be as effective as the other variables in influencing consumption behavior. Despite these results, this does not mean that decision makers should abandon or decrease the level of taxation as taxation still has an effect on consumption as a vital policy lever.

Considering state media expenditures, this type of direct communication to the consumer seems to have different results for cigarettes and petroleum. Government media campaigns on cigarettes are not significant in result and hold a slight positive value on consumption, which contradicts the results from Hu *et al.* (2005a). This shows us that governmental media campaigns have not led to a decreased level of consumption where instead a positive effect is seen. Through statistically insignificant results, however, government media campaigns are less effective to incentivize changing consumption levels. However, as stated by the CDC (2004), industry media spending has outnumbered state spending and as such the government's message may not have been fully received. Thus, it is still vital for the state to increase media advertisements. For government media campaigns on petroleum, however, we do find significant results in the expected negative direction on consumption. With a long term elasticity of -0.523%, this is highest among the variables considered which implies that this indicates to the policymaker that the research campaign, the U.S. Global Climate Change Research Program (USGCRP), has been a valuable policy tool in communicating the effects of overconsumption of petroleum on the environment. Hence, a policy recommendation would be a sustained

[17] This labelling aims to provide information to households regarding their energy consumption, the scale of their environmental impact, and the commodity's energy capacity.

continuation of funding into the program and an expansion of the program across the country. An extension in funding to the USGCRP and an expansion of the program across the country would be another economically viable policy recommendation if the cost of the campaigns is less than the value of lower levels of climate change.

Considering industrial media expenditures, contrasting results are found for tobacco and petroleum. A statistically significant result is found for tobacco, but of a negative sign. This is not the expected result as the goal of industrial media expenditure would be to increase consumption. This would indicate to us that the public may be resistant to messages from the tobacco industry where such reasons may be an increased knowledge of the effects of smoking or that such advertisements may be read by children. This would be an encouraging result to the policymaker, especially as no statistically significant result was found for state media expenditure.

For petroleum, a positive result on consumption was seen but at an insignificant level which shows that the industry's attempt to display themselves in a socially responsible light (i.e. through "greener methods" and with greater safety controls to prevent oil spills) has not appeared to resonate with the public. This may indicate to the policymaker that, along with a significant result for state media expenditure in the expected direction, state policy measures have been effective.

Finally, considering industrial lobbying expenditure, for tobacco and petroleum we see a consistent statistically significant positive effect on consumption. This is of the expected sign where the industry lobbies the government with the aim to increase consumption. This is a worrying outcome as this indicates that lobbying has resonated largely with the public. For tobacco, this contradicts earlier assertions (Givel and Glantz, 2001; Ahrens *et al.*, 2011) on the scope of the tobacco lobby's influence where because of the poor public image the lobby holds, tobacco lobbying was not expected to be largely effective. For petroleum, however, this is not a surprising result where this confirms literature that petroleum lobbying has positive effects on consumption (see, e.g., Kolk and Levy, 2001; Gelbspan, 2004; Kolk and Pinkse, 2007). Through record levels of spending by the petroleum industry, lobbyists may be argued to have successfully tapped into the rampant problem of climate change denialism[18]. These implications stress the importance of maintaining the stock of information to the public on the effects of climate change through media spending. Additionally, the government may consider stricter legislation on lobbyists to curb their influence, e.g. spending limits.

For future research, a further improvement to this study may be a study on the psychological element behind how consumers perceive and react to taxation. It is argued that within the field of consumer behavior from taxation, "what is needed is a comprehensive model on how tax attitudes come about" (Furnham, 1984, pg. 545). Such studies may be comprehensive psychological mapping of consumer behavior as well as how a person's own beliefs may impact their decision. Explicitly, it may also be worthwhile and interesting to conduct a survey analysis for future studies based on values as to how certain 'values groups' may react to the signaling effect. Such values groups may be those who consider themselves religious or not (i.e. Christian, Muslim, Atheist, etc.) or those of a particular political persuasion (i.e. liberal, conservative, etc.).

In Papers [I] and [II], only regulation made by the government is considered. However, producers of harmful commodities also produce their own advertisements and campaigns to boost consumption. As stated by the ASPECT Consortium (2004), tobacco companies are a prime example where despite existing legislation, tobacco companies have launched their own promotion and campaigns to undermine and influence anti-tobacco legislation and to satisfy the "*psycho-social needs*" for current smokers. Likewise, the tobacco industry *"is increasingly*

[18] Where 161 elected officials from the 113th Congress (Jan-June 2013) have taken in over $54 million from the fossil fuel industry to vote against 'green policies' despite an overwhelming scientific consensus on the environmental and financial impacts of climate change[18] (Germain *et al.*, 2013; Spross, 2013)

aware of the need to target children and young adults to assure its future market". Another improvement to the study of the signaling effect from taxation may be inclusion of variables regarding marketing campaigns by the not only the tobacco industry, but for the alcohol or energy industry as well.

The objective of Paper [II] is to provide analysis on the federal level. However, a point of analysis for future research would be a state-by-state study regarding the signaling effect and legislation. A state-by-state analysis would also be able to utilize individual state legislation where such legislation differs state to state. This study assumes that information is held over time in constant terms. However, information held by the consumer may decay over time. Incorporating a decay function within the methodology may take into account such factors. As consumers also import the commodities considered from a state with a lower state tax rate, assessing the impact on such actions would also be interesting to a future study.

Paper [III] is conducted using data on the national level; however, state-by-state differences play a major role on where the federal government should concentrate its policy to ensure decreased consumption. However, in this study, due to data restrictions, data on consumer expenditure and lobbying was not readily available.

An area this paper has not addressed is the divide between political ideologies regarding whether action should be taken by the state to try and influence consumer expenditure of cigarettes and petroleum. As said in the paper, many see government interventions as anti-business or holding potential political bias. This is typically divided amongst Republicans and Democrats where the conservative ideology is argued to try and increase support for the domestic economy feeding opposition to alleged 'government interference' and defending the 'free-enterprise system' (Sutter, 2002). Looking at lobbying, from the Center for Responsive Politics, the party split is quite partisan in nature. For example, in 2012 from the tobacco industry, of $26.7 million spent, $3 million went specifically to Republican lawmakers (79.4%)[19] whilst $779.2 thousand (20.6%) went to Democratic lawmakers. For the oil and gas industry, the divide was even more pronounced where, out of $143.6 million spent, $50.8 million went to Republicans (89.6%) whilst $5.9 million (10.4%) went to the Democrats. A future study may try and look closely at the differences in consumer behavior and reactions to state and industry communication between Republicans, Democrats, and Independents.

[19] Percentages are given as a total of contributions to specific political parties. Contributions not given to specific political parties are given to independent candidates (non-affiliated or belonging to an alternative party) or non-partisan political action committees and organizations.

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I

The Signaling Effect of Environmental and Health-Based Taxation and Legislation for Public Policy: An Empirical Analysis

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Abstract

The main objective of this article is to examine how taxes affect consumption of commodities that are detrimental to health and the environment: tobacco, alcoholic beverages, household energy and petroleum fuel (petrol) for transportation. Specifically, we examine if a tax increase leads to a significantly larger change in consumption than a producer price change, which is referred to as the signalling effect from taxation. This objective is achieved through an empirical analysis using the Linear Almost Ideal Demand System. The analysis uses aggregated cross-sectional time series data and information on major legislation introductions in Sweden, Denmark and the United Kingdom from 1970 to 2009. We find the main result to be that the signalling effect is significant for "Electricity" in Sweden and Denmark and significant for "Electricity" and "Petrol" in the United Kingdom. This implies that tax policy is more effective in tackling consumption of commodities which produce negative public effects (negative externalities affecting the social good such as pollution) than those for negative private effects (negative internalities affecting the private good such as health).

Keywords: almost ideal demand system; legislation; public policy; regulation; signalling; taxation

JEL Classification System-Numbers: C23, D12, H23, I18

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1. Introduction

The main objective of this article is to examine how taxes, a popular policy lever for changing consumer responses, affects consumption of commodities that are detrimental to health and/or the environment. Specifically, this article will investigate whether the effects of a change in consumer prices differs depending on whether the price change is due to a tax change or a change in producer price. If there is a statistically significant difference in the sense that a tax increase leads to a larger change in consumption than from a producer price change, this is referred to as the *signalling effect* of taxation. The existence of the signalling effect would indicate that the standard price elasticities that are used to evaluate tax changes may lead to under-estimation of consumer responses. Additionally, this article will empirically estimate how regulation and information campaigns may interact with taxes and hence reinforce the pure price effect from a tax. For the empirical analysis, this article uses aggregated time series data for Sweden, Denmark and the United Kingdom, covering the period 1970-2009.

Economic instruments, such as taxes, are important tools in order to change consumption patterns among individuals and society. The most popular examples of such taxes are those on tobacco, alcohol, household energy and gasoline for transportation, which at least partly aims to decrease consumption. The basic argument is that there exists a market failure in the sense that the market cost of that harmful good does not fully cover the social cost. By internalizing the external cost with a tax, the individual will adjust its consumption behaviour in the desired direction.

This effect from taxation is assumed to work through the consumer's budget constraint, where for example with tobacco tax, a higher consumer price would then decrease real income, lowering consumption, as well as providing an incentive to substitute away from tobacco. Given this, the standard way to assess the potential effect of a tax is through the price elasticity for the particular good. This simple framework, that the consumer is affected only through the budget restriction, is the focus of attention in this article.

Behavioural economists have supplied arguments questioning the simple mechanism from basic consumer theory into what has been denoted 'signalling theory', which has its roots in contract theory and asymmetric information (Spence 1973, 2002). The overall point is that a consumer may be less informed about the properties of a good than the supplier of that good and the government. For example, a regulator may be 'better informed' through possession of statistics agencies along with specialized research groups. As a result, consumption may be too high or low from both the individual and social point of view. One way to get around this problem is to signal some property of the good. For example, the regulator can launch information campaigns, raise the tax of the commodity or choose both methods. The individual then takes an action that affects the welfare of both parties as consumers associate a monetary value to the impact of their actions (Crawford & Sobel, 1982). Although the level of taxation and amount of legislation forms a distinct correlation with consumption, the signalling effect can be seen as causal where the individual is made aware of the consequences of overconsumption as the problem is made visible to the consumer. As a result we measure this signalling effect through the models we estimate.

For example, a carbon tax may make the driver aware of the pollution problem, and hence changes their behaviour fundamentally. Another argument questioning the standard 'simple theory' is that consumers react according to norms. These social norms are defined as, *"rules developed by a group that specify how people must, should, may, should not and must not*

behave in various situations" (Leslie *et al.*, 1973). Hence changes in norms through signalling the property of the good may fundamentally change consumption patterns. Upon understanding the justification and legitimacy of regulation, public acceptance of regulation and thus tax norm support is more likely (Lindbeck *et al.*, 1999; Benabou & Tirole, 2003; Glaeser, 2006).

However, realistically, taxation cannot effectively transmit signals in isolation. As this missing information holds a public good nature, the government has a key function to disseminate this through mutual communication streams (through e.g. legislation, public information campaigns, etc.) to persuade the consumer to alter beliefs (Licari & Meier, 2000). The basic idea is that the price and/or tax may have a signalling effect, and that such an effect may be reinforced if a change in taxation is combined with a non-price signal, for example changes in legislation such as an informational campaign or limitations in advertising.

The main contribution of this paper is that we test for this kind of signalling effect for different countries and various goods with interactions from legislation (i.e. restrictions, advertising, etc.). Such changes in the signalling effect are analysed specific to an individual country as to give the specific effect for that country[2]. The motivation for this is that this article aims to provide a comparison analysis between these countries rather than show a total result across all three countries done through a panel data test. Through this approach we are also able to include specific legislation introductions for a particular country as these legislations are not equal across all three. This provides the basis for our interpretation into the presence and impact on the signalling effect on harmful commodities. The purpose of this article is to present an analysis on the significance of the signalling effect, but not to test why the signalling effect may be significant for one commodity but not for another.

Another interpretation this article makes is the difference between the signalling effect regarding "public goods" and "private goods". The goods we consider are such that some are characterized as having negative public externalities (petrol and energy) which are public in nature. Overconsumption in this case may produce negative externalities that affect all users (e.g. pollution). However, others are characterized as having mainly private negative internalities (tobacco and alcohol) which are private in nature. Overconsumption of these types of goods may produce negative internalities which primarily affect the wellbeing of the individual consuming that good (e.g. through poor health). An interesting issue is then to test if the effects of taxation and legislation differ depending on the public or private nature of the externality or internality, respectively.

The rest of the paper is structured as follows. In the next section we provide a more detailed background to the problem and a literature review. In section 3 we outline the model used for the empirical analysis and will describe the data we use. Section 4 presents the results from the analysis. Section 5, finally, gives some concluding remarks and prospects for future research.

2. Background and hypotheses

The debate on the performance and relevance of taxation is to a large extent focused on products related to health and the environment, such as tobacco, alcohol and energy. This

[2] As described in Chapter 3.1, the countries we provide specific analysis for are Sweden, Denmark and the United Kingdom.

debate is easy to understand considering, for example, the damage from tobacco consumption. Annually, smoking accounts for five million deaths worldwide (the leading cause of preventable death) and could rise to eight million per year by 2030 if current trends continue (WHO, 2012). To get an idea of how serious the EU takes smoking, one only has to look at the intensified information campaigns and increased advertisements on tobacco products designed to shock smokers[3] through damage caused by tobacco. This further follows and adds to vigorous international campaigns and strategies from the WHO Framework Convention on Tobacco Control (EU, 2004). Today, plans to raise taxes on tobacco products continue across the EU where the World Health Organization (WHO) states, "*Increasing the price of tobacco products through significant tax increases is the single most effective way to decrease tobacco use and encourage current users to quit"* (WHO, 2009). While this may be true, there seems to be no robust analyses on the effects of the signalling effect within tobacco taxation in the EU, and specifically how taxes as a signal may change the fundamental behaviour of individuals. Concerning estimates of the price elasticity for tobacco, a large variation between individuals exists where, according to a review by Wilson *et al.* (2012), the price elasticity ranges from -0.1 to -1.41 among youths, and 0.1 to -0.45 for adults.

Similarly, alcohol accounts for a substantial economic burden through morbidity and mortality of 2 billion people worldwide annually. Furthermore, alcohol accounts for 1.8 million deaths and 76.3 million diagnosable alcohol use disorders per year as well as many incidences of drunk driving, disorderly conduct and alcohol-related violence (WHO, 2002). In a review by Wagemaar *et al.* (2009) of 1,003 estimates, from 112 different studies they find a mean of the price elasticity ranging between -0.46 (beer) and -0.80 (spirits). Overall there seems to be a large variation between individuals, not the least depending on the level of consumption. Direct policy measures targeting all drinkers (e.g. policies on taxation advertising, availability controls, etc.) are argued to have had clear effectiveness. Specifically, a review of 112 studies (Wagenaar *et al.*, 2009) on the effects of alcohol tax affirms that when alcohol taxes go up, consumption goes down. However, the result as to whether taxation is effective on signalling information to the consumer remains untested. As for tobacco, there seems to be no robust analyses on the effects of alcohol taxation having signalling effects in the EU.

Since the 'environmental revolution' of the 1960s, the global energy crisis of the 1970s and the 'Green Tax Reforms' of the early-1990s, carbon taxes have been called for to combat the negative impacts of petrol and household energy consumption. While energy use per se is not bad, the negative external effects from consumption of petrol and energy, e.g. pollution, are what we consider here when speaking of 'energy use'. Through these challenges our world faces, additional study on the magnitude of consumer responses and behaviour to taxation and legislation are greatly needed (OECD, 2003). The current stock of motor vehicles in OECD countries is expected to grow 32% by 2020 whilst motor vehicle kilometres are projected to increase by 40% (OECD, 2002). For household electricity consumption, energy use in OECD countries grew by 36% from 1973 to 1998 and is expected to grow by 35-51% worldwide for the next 20 years (OECD, 2002).

We have seen many information campaigns about minimizing electricity and petrol when not needed, as well as purchasing energy saving appliances and 'green vehicles'. However, direct taxation carries a risk of a political and social backlash. Most governments seek to stamp out or minimize consumption of tobacco and alcohol. Petrol and electricity consumption, on the other hand, forms a day to day expense for households which display a different form of

[3] Such shocking measures include images of rotten lungs, decaying teeth, a baby with an oxygen mask and a man with a cancerous tumor on his throat.

'addiction' as it is technically difficult to find substitutes. This is to some extent revealed through demand being relatively inelastic,[4] especially in the short run.

An argument against taxes that has been put forward is that if consumers are very much against tax increases or already abstain from 'undesirable behaviour', they may even increase consumption leading to a 'boomerang effect' from attempting to discourage consumption in the first place (Kallbekken *et al.*, 2010). For example, considering carbon tax, if a household already uses less energy than others or believes their free choices are being affected, then appeals to the social norms may instead lead to a "boomerang effect" where it may actually lead to increased energy use. Furthermore, as pointed out by Truyts (2008), if consumers cannot distinguish the taxed from the untaxed specimens, then taxes might impair the informational value of this commodity. If the signaling effect is quite small or non-existent, it does not mean that taxes are ineffective; it just indicates that responses to the tax are similar to 'ordinary' price changes. However, in this case, policy recommendations of increased soft paternalism, i.e. increased informational campaigns, may be more advisable to achieve the government's aims rather than increased focus on taxation.

Actual empirical studies regarding signaling within commodity taxation has been very limited despite many articles on the application of information economics within taxation. Overall, two papers, to the author's knowledge, explicitly explore the signaling effect empirically. Licari and Meier (2000) focus on US cigarette consumption from 1955 to 1996 through pooled-time series OLS estimation where the main hypothesis was that, *"when the tax on cigarettes increases, there is an additional signaling effect besides the price increase"*. To take account of major tobacco legislation introductions, interaction terms are added between the lagged dependent variable for past consumption as an independent variable. The results how that a 1% increase in the tax as a percentage of prices is associated with a 0.15% decrease in per capita consumption, where a clear signaling effect separated from a pure price increase is observed.

While Licari and Meier (2000) focused on the US, there are no studies on the signaling effect considering European tobacco consumption. Thus a clear need for development of a European perspective is evident. A feature from Licari and Meier directly influencing this study is the specific modelling of legislation introductions through interaction terms with the tax. The main motivation for this is that legislation shocks cannot be viewed in isolation from tax changes. Furthermore, this paper expands upon this by not only focusing on cigarettes but also other forms of tobacco.

Ghalwash (2007), through a system of household demand equations and a three-stage budgeting process[5], considers Swedish environmental taxes using time series data[6] for different commodity groups[7] from 1980 to 2002. The main hypothesis put forward by Ghalwash is that changes in taxation send a different signal than pure price changes. For appropriate demand function estimates, the AIDS (Almost Ideal Demand System) and subsequent Linear Almost Ideal Demand System (LAIDS), first derived by Deaton & Muellbauer (1980b) was employed. The main result was that changes in environmental taxes had a significant signaling effect on the demand for residential heating where consumers are more sensitive to a tax change than a producer price change. For petrol within transports, the opposite is seen.

[4] Transport fuel demand for example is estimated to have a short-term elasticity of around -0.3 and a long-term elasticity from -0.6 and -0.8 (Sterner, 2006)

[5] Evolving from the two-stage budgeting process for household demand (Gorman, 1959; Berkhout *et al.*, 2004)

[6] Data includes taxation, household expenditure consumer price and producer price index levels

[7] Split into four main groups: "Foodstuff", "Transport", "Heating" and "Other goods"

However, in Ghalwash (2007), significant legislation effects are assumed to be implicitly included within the tax function. In this study we will expand on Ghalwash (2007) by including interaction effects on taxation from introduction of legislative campaigns explicitly. Legislation campaigns are, for example, introduction of smoking bans in places of employment which play a large part to consumer behaviour. This method is explained and backed up in the methodology section. Considering numerous countries (apart from just Sweden) along with an extended timeline (including the 1970s-decade) and a more detailed demand model in this study will extend and improve upon Ghalwash's contribution.

However, as the central aim of this paper is to analyse the impact from the signaling effect from taxation, we do not consider how taxes or legislation is decided. Nor do we consider what makes policymakers introduce certain taxes or legislation at a specific time. Furthermore, this study does not present a formal analysis as to why differences exist for taxation elasticities among various commodity groups or across countries. Such obvious reasons for such differences among commodity groups may be the addiction level for commodities such as tobacco and alcohol. Such an addictive factor is not present for household energy. For petrol however, there is a technical 'addiction' as petrol is difficult to substitute in a household's budget. Further reasons for differences across countries are even more numerous, i.e. cultural attitudes, infrastructure and education levels.

The main point of this paper is to present an outlook into the significance regarding the signaling effect of taxation from 1970 to 2008. Thus, the first and main hypothesis to test for is:

Hypothesis 1: There exists a signaling effect of taxation on a given commodity of a significant value.

One of the key points of this article is the difference between public and private effects. Petrol and electricity consumption produces primarily public negative external effects whilst the negative externalities from tobacco and alcohol are primarily private in nature, although they also negatively affect the public well-being through increased costs for health care. To test if the effects of taxation and legislation differ depending on the nature of the good, we aim to answer the following hypothetical hypothesis:

Hypothesis 2: The signaling effect is greater for taxation on commodities that produce negative private effects as opposed to public effects.

3. The model and data

This section will detail the model and data that will be used in the empirical analysis. To model consumer behaviour, this paper implicitly adapts a three-stage budgeting model where the first stage assumes that the cost-minimizing household determines how much to spend on leisure consumption, savings and consumer goods. Second, given a total budget, the household allocates its total expenditure for commodity groups, i.e. foodstuff, transport, etc. Third, the household allocates expenditure on specific commodities within each group, given its budget for the commodity group. Through data analysis, I will conduct a time series study over the given time period for each commodity.

3.1 Modelling approach

The model employed in this article expands upon the basic form of the AIDS (Almost Ideal Demand System) model first developed by Deaton & Muellbauer (1980b) and used by Ghalwash (2007). The AIDS model is a flexible form specification of preferences, while

allowing for weak seperability, which means that commodities can be classified into specific commodity groups as described above.

In its basic form, we may write the system of demand functions, in budget share form as:

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_{jt} + \beta_i \ln(x_t/P_t) + \varepsilon_{it}\,; \quad i = 1, \dots, n \tag{1}$$

where w_{it} denotes the budget share for commodity i in period t, p is the corresponding consumer price, x is the total expenditure on consumption, and P is an aggregated consumer price.

In order to separate the effects from taxation as opposed to price changes, it is necessary to partition the consumer prices into the producer price and tax elements. Letting tax_j be the unit tax on commodity j, we may express the consumer price as $p_j = \overline{p}_j + tax_j$. We may then define the implicit tax on commodity j as:

$$\tau_j = \frac{tax_j}{\overline{p}_j}$$

which enables us to express the consumer price as:

$$p_j = \overline{p}_j(1 + \tau_j) \tag{2}$$

Substituting this into equation (1) gives us then:

$$\begin{gathered} w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \left(\ln \overline{p}_{jt} \left(1 + \tau_{jt}\right)\right) + \beta_i \ln(x_t/P_t) + \varepsilon_{it}\,; \quad i = 1, \dots, n \\ w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln \overline{p}_{jt} + \sum_{j=1}^{n} \gamma_{ij} \ln\left(1 + \tau_{jt}\right) + \beta_i \ln(x_t/P_t) + \varepsilon_{it}\,; \quad i = 1, \dots, n \end{gathered} \tag{3}$$

Allowing for different parameters representing the producer price and taxation, we may then rewrite equation (3) to be estimated as:

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln \overline{p}_{jt} + \sum_{j=1}^{n} \tilde{\gamma}_{ij} \ln\left(1 + \tau_{jt}\right) + \beta_i \ln(x_t/P_t) + \varepsilon_{it}\,; \quad i = 1, \dots, n \tag{4}$$

Our central interest in this study is the magnitude of γ_{ij} representing the producer price, and $\tilde{\gamma}_{ij}$, the coefficient for taxation. By capturing the differences between these two parameters, we can estimate the effects of taxation on consumer behaviour.

To detail the logic behind the model, when purchasing a commodity, the consumer takes into account the overall consumer price which includes the producer price and taxation plus a pure effect of taxation. This principle can be described by the following relationship as given by equation (4) (omitting summations and subscripts):

$$w = \alpha + \gamma \ln\left(\overline{p}(1 + \tau)\right) + (\tilde{\gamma} - \gamma) \ln(1 + \tau) + \beta \ln(x/P) + \varepsilon \tag{5}$$

From equation (5) we see that we have a positive signaling effect if $\tilde{\gamma} > \gamma$. On the other hand, if the difference between the parameters approaches zero, this indicates no specific signaling effects since the effect of a tax change equals the effect of a producer price change. Furthermore, if we see that $\gamma > \tilde{\gamma}$, this indicates that producer price has greater explanatory power where consumers are either resistant to taxation or where the tax effect isn't fully

recognized. The objective here then is to test whether the difference between these two parameters is significant or not.

The demand system resulting from the second stage, i.e. allocation of the total consumption budget over commodity groups, can be expressed as:

$$w_{(r)t} = \alpha_{(r)} + \sum_{s=1}^{n} \gamma_{(r)(s)} \ln \overline{p}_{(s)t} + \sum_{s=1}^{n} \tilde{\gamma}_{(r)(s)} \ln\left(1 + \tau_{(r)(s)}\right) + \beta_{(r)} \ln(x_t / P_t) + \varepsilon_{(r)t}\,; \quad r = 1, \dots, n \tag{6}$$

where $r = 1, \dots, n$ denote commodity groups. Here $w_{(r)t}$ is the budget share for group r at time t, x_t is the total expenditure of non-durable commodities, $\tau_{(r)t}$ is the implicit tax rate for commodity group r at time t, $\overline{p}_{(r)t}$ is the group producer price and P_t is the consumer price for non-durables.

Considering the third stage, the demand for commodities within groups, possible effects from legislation and information is allowed for. This is done through a set of dummy variables, representing major legislative reforms or information campaigns upon the point of implementation. These dummies are interacted with the tax variable. The basic idea is that legislation and information may reinforce the tax effect.

The demand system resulting from the third stage, i.e. the demand for each individual commodity i within group r is then:

$$\begin{aligned} w_{i(r)t} = \alpha_{i(r)} + \sum_{j=1}^{m(r)} \gamma_{ij(r)} \ln \overline{p}_{j(r)t} + \left(\sum_{j=1}^{m(r)} \tilde{\gamma}_{ij(r)} + \sum_{m=1}^{M} \psi_m L_m \right) \ln\left(1 + \tau_{ij(r)}\right) \\ + \beta_{i(r)} \ln\left(x_{(r)t} / P_{(r)t}\right) + \sum_{m} \mu_m L_m + \varepsilon_{i(r)t} \end{aligned} \tag{7}$$

where $i = 1, \dots, m(r)$ denote commodities within group r. Equation (7) describes the allocation of expenditure within the commodity group. Here, $w_{i(r)t}$ is the budget share for good i within commodity group r, $x_{(r)t}$ is the total expenditure allocated to commodity group r, $\overline{p}_{i(r)t}$ is the producer price for good i in commodity group r, $\tau_{ij(r)}$ is the implicit tax rate of good j within commodity group r, and $P_{(r)t}$ is the Stone price index for the rth commodity group. Following Deaton & Meullbauer (1980b), Moschini (1995), and Ghalwash (2007), P is replaced by Stone's Price Index which allows for a linear demand approximation which is calculated as:

$$\ln(P) = \sum_{j} w_j \ln\left(p_j\right)$$

This paper also introduces possible effects of advertising and legislation. From this we can see the estimated effects of taxation when controlling for these effects. We denote the advertising and legislative effects as an array of m dummy variables denoted by L with coefficient μ which takes the value of 0 at 1970 and then 1 for each major advertising/legislative change[8]. This is introduced at the final stage of the three-stage budgeting decision where this legislation is targeted at a specific commodity rather than a commodity group. For example, with two major additions of legislation (in 1982 and 2004) we have as below:

$$\mu_2 \boldsymbol{L}_2 = \begin{pmatrix} 0 & \mu_1 & \mu_2 \end{pmatrix} \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{pmatrix} \tag{8}$$

[8] Details on the determination of these values are explained in section 2.2 and illustrated in Appendix A

From this it is shown that each legislative increase is collected, added and reflected within the consumption behaviour of the household as an index of regulatory pressure. It is assumed that the coefficient, μ, for this legislative variable is not equal across time but where there is an individual effect from each law passed. This is confirmed by with an F-test showing that $\mu_1 \neq \mu_2 \neq \mu_3$. Whilst logically it may be the case that the effects of legislation on consumer behavior may decay over time as it loses its impact or relevance, for simplicity, we assume long term memory across households having zero decay over time concerning legislative effects. For example, bans and restrictions are constantly re-enforced to the consumer through a constant effect. To fully incorporate the effects of the legislative increases, it is appropriate to include interaction effects to the tax element. This is seen in equation (7) given by ψ_m for m legislative introductions. The coefficients for taxation and the interaction effect are added together where both influence the consumers' consumption decision.

Given estimates of the parameters in equation (6) and (7), we can evaluate consumers' sensitivity to a tax change compared to a pure price change, i.e. the price and tax elasticities, as well as the income, or expenditure, elasticities. Calculations of the own-price and expenditure elasticities are done at both stages, i.e. between and within groups.

The between group elasticities are calculated as:

$$E_{i(r)} = \frac{\beta_{i(r)}}{w_{i(r)}} + 1; \quad r = 1, \dots, n \tag{9}$$

$$e_{i(r)} = \left(\frac{\gamma_{i(r)} - \beta_{i(r)} w_{(r)}}{w_{i(r)}} - \delta_{i(r)} \right); \quad r = 1, \dots, n; s = 1, \dots, n \tag{10}$$

$$\tilde{e}_{i(r)} = \left(\frac{\tilde{\gamma}_{i(r)} - \beta_{i(r)} w_{(r)}}{w_{i(r)}} - \delta_{i(r)} \right); \quad r = 1, \dots, n; s = 1, \dots, n \tag{11}$$

where $E_{i(r)}$ denotes the expenditure elasticity for commodity i in group r, $e_{i(r)}$ is the uncompensated producer price elasticity, and $\tilde{e}_{i(r)}$ is the uncompensated tax elasticity. Furthermore, $\delta_{i(r)}$ is equal to one when $r = s$ and zero otherwise.

For the tax elasticity corresponding to individual commodities (equation 11), the interaction term is again added along with the coefficient for taxation. Thus we can write equation (11) as:

$$\tilde{e}_{i(r)} = \left(\frac{\left(\tilde{\gamma}_{i(r)} + \psi_m L_m\right) - \beta_{i(r)} w_{(r)}}{w_{i(r)}} - \delta_{rs} \right); \quad i = 1, \dots, n; r = 1, \dots, n \tag{12}$$

The existence of the signaling effect is seen from this model through a difference between the elasticities for the producer price and the tax element. No significant difference between these elasticities may indicate that the increase in tax and an increase in producer price would have the same magnitude of effect. Having the expenditure elasticity of demand analysed along with this would be able to tell us to what degree the change in consumer's expenditure (a proxy for income) influences this line of analysis.

Allowing the expenditure elasticity within the *r*th group to be $E_{(r)}$, we may denote the total expenditure elasticity for the *i*th good within the *r*th group of goods, $E_{i(r)}$ to be:

$$E_i = E_{(r)} E_{i(r)} \tag{13}$$

Through the similar principle, we can express the within own-price elasticity of the *i*th good within the *r*th group of goods as $E_{i(r)}$. Thus the total price elasticity for the *i*th good within the *r*th group of goods, e_{ij}, can be expressed as:

$$e_{ij} = \delta_{i(r)} e_{ij(r)} + E_{i(r)} w_{j(r)} \left(\delta_{i(r)} + e_{i(r)}\right) \quad (14)$$

This total price elasticity consists of two components. The first part, being the direct effect, represents the subgroup elasticity. The second part is the indirect effect which is a product of three factors. The first of these factors measures the relative change in the group price index when the price of the *i*th good changes (equal to the budget share). The second factor measures the effect a change in the price index has on the group expenditure $\left(1 + e_{i(r)}\right)$. Finally the third factor measures the effect of the change in within group expenditure has on the consumption of the *i*th good $\left(E_{i(r)}\right)$.

3.2 Description of the Data

This paper uses largely publicly available datasets covering the years 1970-2009 from the statistics agencies within Sweden, Denmark and the United Kingdom[9]. The main reason for choosing these countries, apart from data reasons, is that Sweden and Denmark are the highest taxed countries in Europe; also as the UK holds very high levels of taxation for tobacco and alcohol products, this paper conducts a 'study of extremes'. It is the interesting to gather a comparison from countries with higher tax rates than most.

Indices used are household expenditure (in current prices) as well as producer and consumer prices. The dataset cover five main commodity groups: "Foodstuff", "Household energy and utilities", "Furnishings and household goods" as well as "Apparel, textiles and maintenance". Within these commodity groups we then analyse a set of individual commodities. The commodities within "Foodstuff" are "Tobacco", "Alcoholic beverages", "Spirits and Wine", "Beer", "Meat", "Fish and seafood", "Dairy products" and "Non-alcoholic beverages". The commodities within "Household energy and utilities" are "Petroleum for personal transport (Petrol)", "Electricity and gas" and "Electricity". "Household appliances" constitute the "Furnishings and household goods" commodity group, while "Clothing and footwear is the commodity within the "Apparel, textiles and maintenance" group. The data structure is presented in Tables 1-3 along with corresponding budget shares[10] for the: (i) budget share against total consumption expenditure, and (ii) budget share against consumption expenditure for the commodity group. For each commodity group, budget shares are given against the total consumption expenditure. We see that each group contains other commodities that we do not analyse in this article and hence are placed in the box named "Other". In order to measure the individual effects of the signaling effect for spirits and wine as well as beer, these are included as subsets of alcoholic beverages which are the summation of these two values. The same is done for electricity which is a subset within electricity and gas (thus marked in italics) where producer prices for gas are not available for the length of the timeline available for electricity.

For certain countries, producer price data is not available for natural gas across the full timeline, so this cannot be analysed individually. Furthermore, for the United Kingdom, as producer price data is restricted for alcoholic beverages before 1974, the timeline for foodstuff commodities will be from 1974 to 2009. As non-alcoholic beverages must be analysed as substitutes for alcoholic beverages to fit in with our model's three-stage household budgeting process, each foodstuff commodity must have the same starting point.

[9] Statistiska Centralbryån (SCB) in Sweden, Danmarks Statistik in Denmark and the Office of National Statistics in the United Kingdom

[10] Taken as the average value of budget shares from 1970-2008

Table 1: Commodity Group and Individual Commodity Budget Shares - Sweden:

Commodity Group	**Budget Share**	**Individual Commodity**	**Budget Share**
Foodstuff	0.2137	Tobacco	(i): 0.0194 (ii): 0.0910
		Alcoholic beverages	(i): 0.0311 (ii): 0.1438
		Spirits and wine	(i): 0.0223 (ii): 0.1020
		Beer	(i): 0.0084 (ii): 0.0418
		Meat	(i): 0.0274 (ii): 0.1287
		Dairy products	(i): 0.0261 (ii): 0.1224
		Fish and seafood	(i): 0.0089 (ii): 0.0421
		Non-alcoholic beverages	(i): 0.0156 (ii): 0.0732
		Other Foodstuff	(i): 0.0852 (ii): 0.3988
Household energy and utilities	0.2958	Petrol	(i): 0.0372 (ii): 0.2959
		Electricity and gas	(i): 0.0294 (ii): 0.1120
		Electricity	(i): 0.0288 (ii): 0.1098
		Other Household energy and utilities	(i): 0.2292 (ii): 0.5921
Furnishings and household goods	0.0478	Household appliances	(i): 0.0042 (ii): 0.0863
		Other furnishings and household goods	(i): 0.0436 (ii): 0.9137
Apparel, textiles and maintenance	0.0581	Clothing and footwear	(i): 0.0574 (ii): 0.9884
		Other Apparel, textiles and maintenance	(i): 0.0007 (ii): 0.0116
Other commodity groups	0.3846		

Table 2: Commodity Group and Individual Commodity Budget Shares – Denmark:

Commodity Group	**Budget Share**	**Individual Commodity**	**Budget Share**
Foodstuff	0.2045	Tobacco	(i): 0.0287 (ii): 0.1382
		Alcoholic beverages	(i): 0.0302 (ii): 0.1451
		Spirits and wine	(i): 0.0144 (ii): 0.0714
		Beer	(i): 0.0158 (ii): 0.0737
		Meat	(i): 0.0345 (ii): 0.1683
		Dairy products	(i): 0.0165 (ii): 0.0824
		Fish and seafood	(i): 0.0067 (ii): 0.0322
		Non-alcoholic beverages	(i): 0.0173 (ii): 0.0849

		Other Foodstuff	(i): 0.0706 (ii): 0.3489
Household energy and utilities	0.2168	Petrol	(i): 0.0286 (ii): 0.1295
		Electricity and gas	(i): 0.0253 (ii): 0.1336
		Electricity	(i): 0.0205 (ii): 0.1083
		Other Housing and household energy	(i): 0.1629 (ii): 0.7369
Furnishings and household goods	0.0643	Household appliances	(i): 0.0100 (ii): 0.1558
		Other Furnishings and household goods	(i): 0.0543 (ii): 0.8442
Apparel, textiles and maintenance	0.0553	Clothing and footwear	(i): 0.0533 (ii): 0.9669
		Other Apparel, textiles and maintenance	(i): 0.0020 (ii): 0.0331
Other commodity groups	0.4591		

Table 3: Commodity Group and Individual Commodity Budget Shares – United Kingdom:

Commodity Group	**Budget Share**	**Individual Commodity**	**Budget Share**
Foodstuff	0.1865	Tobacco	(i): 0.0308 (ii): 0.1641
		Alcoholic beverages	(i): 0.0188 (ii): 0.1057
		Spirits and wine	(i): 0.0135 (ii): 0.0767
		Beer	(i): 0.0052 (ii): 0.0291
		Meat	(i): 0.0343 (ii): 0.1769
		Dairy products	(i): 0.0193 (ii): 0.1006
		Fish and seafood	(i): 0.0047 (ii): 0.0255
		Non-alcoholic beverages	(i): 0.0125 (ii): 0.0708
		Other Foodstuff	(i): 0.0661 (ii): 0.3564
Housing and household energy	0.2053	Petrol	(i): 0.0317 (ii): 0.2215
		Electricity and gas	(i): 0.0336 (ii): 0.1962
		Electricity	(i): 0.0191 (ii): 0.1127
		Other Housing and household energy	(i): 0.1400 (ii): 0.8138
Furnishings and household goods	0.0630	Household appliances	(i): 0.0115 (ii): 0.1815
		Other Furnishings and household goods	(i): 0.0515 (ii): 0.8185
Apparel, textiles and maintenance	0.0688	Clothing and footwear	(i): 0.0667 (ii): 0.9698
		Other Apparel, textiles and maintenance	(i): 0.0021 (ii): 0.0302
Other commodity groups	0.4764		

Figures 1-3 in Appendix A illustrate the development over time of the household budget shares for tobacco, alcohol, electricity and petrol for each of the countries. Figure 1 shows that for Sweden there has been a steady negative trend in tobacco and alcohol consumption, in terms of its budget share. However, there has been a steady upward trend for electricity and a slight upward trend on average for petrol. It is interesting that tobacco until 1978 and alcohol until 1991 had a larger budget share than electricity. However as the price for electricity was very low in the 70s, this may provide an explanation as to why.

For Denmark (Figure 2), we see that the budget shares for tobacco and alcohol have been very close and have had a steady decrease over time. Petrol, on the other hand, has been stable over time, whereas the budget share of electricity has had a slight increase since 1970. For the United Kingdom, Figure 3 exhibits a different pattern over time than Sweden and Denmark. The budget shares for alcohol and electricity are close to one another over the time period, and both decrease slightly over time. Tobacco has a very large drop in budget share over time, which seems to be consistent with the large price increases over time the UK.

Major legislation refers to legislation enforced on the four key commodities that this paper considers. To maintain consistency, these legislation introductions consist of major [11] implemented domestic or EU-wide policy directives aimed at the consumer, e.g. bans, restrictions and significant advertising campaigns. This paper ignores so-called 'voluntary agreements' as often companies producing the harmful commodity may circumvent these agreements as no penalty is given for breach of the agreements (Simpson & Lee, 2002). Details of implemented policy directive are given in Appendix B[12].

For tobacco, we see that legislation has been quite extensive in all three countries, with the most in the UK. Alcohol legislation, however, seems to be plentiful in Sweden whilst less implemented in Denmark and the UK. This is due to the fact that Denmark and the UK has a system preferring self-regulation for alcohol as opposed to involuntary formal legislation. We can see that for petrol and household energy consumption, few legislation introductions are aimed at consumers but rather aimed at suppliers and producers of household energy and petrol. General awareness campaigns are few in number as these are generally considered by most countries as not effective in promoting more sustainable consumption patterns, largely due to the fact that public authorities face tough competition from the private sector for public attention (OECD, 2008).

4. Results

From the specifications of the LAIDS model given by equations (7) and (8), the demand model is estimated (equation by equation) for the commodity groups and individual commodities within the group through OLS regression with robust standard errors. Robust standard errors are used as to be ensuring efficiency (or robustness) of estimation in the case of potential outliers. All details of the estimations are given in Appendix C. Certain coefficients representing the interaction terms are omitted from analysis due to collinearity with its corresponding legislation term and thus labelled in Appendix C as "omitted". It appears from these results, that the degree of explanation is quite satisfactory and a large part of the estimated coefficients are statistically different from zero.

[11] The term 'major' is given based on the discretion of the author given the impact of the legislation.

[12] Tables 1-3 refer to tobacco legislation; tables 4-6 refer to alcohol legislation; table 7-9 refer to transport fuel legislation; tables 10-12 refer to energy for household energy legislation

The estimates for the estimated interaction terms for the legislation introductions allow us to present a direct effect on the taxation term in the LAIDS model, which is assumed to be an independent effect. This article does not consider whether there are differences in significance with and without inclusion of legislation interactions. Instead that we assume that is the case where taxation as mentioned earlier produces an independent effect and complementary to taxation.

4.1 Legislation

Considering the effects of legislation on the signaling effect of taxation, this article considers the interactions that legislation introductions have on pure price effect of taxation. To this point, we consider the interaction effects on taxation where legislation provides a simultaneous influence on the existing effects from taxation on consumer behaviour. From the results in Appendix C, we are able to see whether this interaction effect has an impact of a significant value. For example, a significant value for interaction term 1 ("Int. Term 1") in the tobacco equation would correspond to the interaction term for the first legislation introduction (which is listed in Appendix B). Here, the first piece of legislation was in 1975, so a significant interaction term would imply that "Int. Term 1" has a significant influence affecting the ability of taxation to change the consumers' consumption decision. A significant positive value would suggest that the legislation introduction crowds out the tax effect where consumers may be more resistant to that legislation introduction. A significant negative value, however, would imply that legislation reinforces the tax effect to reduce consumption on that commodity.

For Sweden, considering tobacco there exists seven legislation terms in which we see that there is significance in Int. Term 3 (1994) of a negative value. This legislation introduction mainly refers to bans on smoking in public places as well as restrictions on advertising for tobacco products. For alcohol, as well as spirits and wine, we see significant interaction effects in none of the legislation introductions. This implies that there is no significant influence of the performance of taxation. However, for beer we see significant interaction terms for Int. Term 3, 4 and 5 (1987, 1994 and 1996, respectively). Here, Int. Terms 3 and 5 are of a negative value which refers to labelling on alcoholic strength, tighter regulation of media advertisement of alcoholic beverages and messages against excessive consumption. However, Int. Term 4 (further restrictions on product control and ordinance of alcoholic beverages) is of a positive value where consumers may be resistant to further legislation.

Regarding legislation on petrol, we find a significant interaction term for Int. Term 3 (1999) of a positive value, which implies this legislation introduction may crowd out the tax effect. Specifically this legislation introduction refers to requiring vehicle dealers to include in each vehicle and petrol selling location the fuel consumption and CO_2 emission figures of that vehicle. Finally, for household energy legislation, we find no significant interaction terms for "Electricity" but significant interactions for Int. Term 1 and 3 (negative for 1992 and positive for 2007, respectively) for "Electricity and Gas". Here, the legislation introduction in 1992 refers to the labelling of appliances and light bulbs to provide information to households regarding their energy consumption and environmental impact. The legislation introduction in 2007 refers to advice by local governments to provide climate change advice to households.

Looking at legislation introductions in Denmark, from the seven legislation introductions for tobacco we see a significant interaction effect for Int. Term 3 but of a positive value. As with Sweden, these refer to legislation on the labelling and advertising of tobacco products as well as enforced smoking bans. For "Alcoholic Beverages", we find no significant interaction effects. However, considering subsets of "Alcoholic Beverages", for "Spirits and Wine" we find

a significant effect for Int. Term 1 of a positive value. This refers to alcoholic strength labelling. For "Beer" we find significant interaction effects for Int. Terms 2 and 3 (positive for 1997 and negative for 2000 respectively). For the legislation introduction in 1997, this refers to the Broadcasting Act prohibiting media advertisements of high strength alcoholic products and further restrictions on lower strength alcoholic products. For the legislation introduction in 2000, this refers to introduction of labelling on allergenic effects of alcohol consumption.

Regarding legislation on petrol, we find significant interaction effects on Int. Terms 2 and 3 (positive for 1992 and negative for 1999) which refer to (in 1992) legislation labelling on motor vehicles describing the amount of CO_2 emissions per kilometre travelled. For the legislation introduction in 1999 this refers to advice to households on how to minimize fuel consumption and the impact of CO_2 emissions. Finally, regarding household energy we find only one significant interaction term for "Electricity and Gas" for Int. Term 1 of a negative value. This legislation introduction in 1992 refers to labelling on household appliances and light bulbs listing the energy efficiency, environmental impact and energy capacity of that product.

Lastly, for the United Kingdom, considering tobacco there exists nine legislation introductions for tobacco in which we find significant interaction effects on Int. Term 3 (1991) of a negative value. This refers to increased penalties for sales of tobacco products to underage persons as well as requirements for health warning labels on tobacco products and retail premises. For "Alcoholic Beverages" and its subset "Beer" we, however, see that none of the interaction terms has a significant impact on influencing taxation's ability to change consumer behaviour. However, for "Spirits and Wine", we see a significant positive interaction effect for Int. Term 3 regarding alcoholic allergenic effects labelling.

Regarding legislation on petrol, we find a statistically significant (negative) interaction effect in Int. Term 5 (2001). This refers to, information campaign material on the level and impact of carbon emissions that the purchased vehicle produces. Finally, for household energy we find a significantly negative interaction effect for Int. Term 1 in "Electricity" (1992) and a significant positive interaction effect in Int. Term 2 (2007). The legislation introduction in 1992 refers to energy labelling on household appliances and light bulbs listing the energy efficiency, environmental impact and energy capacity of that product. The legislation introduction in 2007 refers to information given to households from local councils on the energy efficiency and usage for that households and recommendations on improvement.

4.2 Parameter Equivalence

Following estimation of the parameters from the regression, it is important to first test if the parameters for producer price and taxation are equal or not. This is done through a two-tailed Wald test of the linear hypothesis presented in Appendix D (Tables 1-3). The test indicates to us if the parameter for producer price is larger than or less than the parameter for taxation. An advantage of using this method, as opposed to the Chow test for parameter equality, is that there is no maintained assumption that sample variances for the parameters are equal throughout the timeline. If the parameter for producer price is equal to the parameter for taxes, this would indicate both variables have the same effect on consumption. If the main null hypothesis (in column 3) may be rejected that the parameter for producer price is larger than that of taxation (whilst the other may not be rejected), this would conclude to us that taxation holds more persuasive power in changing consumption than producer price in general. If both null hypotheses cannot be rejected, we assume that the two parameters are assumed equal. For Sweden we may reject the null for alcoholic beverages, beer and electricity. For Denmark

we may reject the null for only electricity and electricity and gas. For the United Kingdom we may reject the null for beer and petrol.

4.3 Elasticity Results

Given the parameter estimates, we can now calculate the expenditure and price elasticities according to equations (7)-(8). Using the mean value for the producer price, taxation and total expenditure from 1970 to 2011 we may calculate the own-price and expenditure elasticities. To test whether the elasticities are significant we use the bootstrap method with 10,000[13] repeated random samples of the LAIDS model. Bootstrapping here is advantageous as it does not assume a specific probability distribution of the data, but relies on the empirical distribution (Wehrens *et al.*, 2000). This is especially the case with nonlinear functions of estimated parameters as in the case here. Here robust and sensible estimates are calculated while a basic F-test could fail to do so.

The main objective with this study is to empirically assess how consumers react to changes in price, taxation and legislation, and hence if there is any difference on the effect on consumption resulting from the source of the price change. Through the linear almost ideal demand model system used and the resulting elasticities, this has been achieved through partitioning producer price and taxation from consumer prices. Specifically, does the pure tax effect send a separate signal on top of the price effect indicating that the commodity is harmful for the private or the public good? This is investigated through controlling for major changes in legislation aimed explicitly at consumers across Sweden, Denmark and the United Kingdom to see if there is a significant difference between the pure tax effect and the producer price. A summary of these results can be found below in for the commodity group and the individual commodity where a significant signaling effect is represented per country.

Table 4a: Estimated own-price and expenditure elasticities – Sweden – Commodity Groups:

Main Commodity Groups	**Own-price**	**Expenditure**
Foodstuff Price	-0.751	0.664
Foodstuff Tax	**-1.046*****	
Household Energy and Utilities Price	-0.665	0.678
Household Energy and Utilities Tax	**-0.940*****	
Furnishings and Household Goods Price	-0.614	1.785
Apparel, Textiles and Maintenance Price	-1.516	1.430

***, **, *: Significant at the 1%, 5% and 10% levels respectively

Table 4b: Estimated own-price and expenditure elasticities – Sweden – Commodities:

Commodity	**Own-price**	**Expenditure**	**Total own-price**	**Total Expenditure**
Foodstuff				
Tobacco Price	-1.027	0.532	-1.029	0.353
Tobacco Tax	-0.281		-0.280	
Alcoholic Beverages Price	-0.883	0.664	-0.877	0.441
Alcoholic Beverages Tax	-1.166		-1.167	
Spirits and Wine Price	-1.637	0.713	-1.633	0.473
Spirits and Wine Tax	-1.996		-1.997	

[13] As available computing power has increased over the years, it is recommended from economic literature that 10,000 bootstrap samples are appropriate.

Beer Price	0.251	0.215	0.251	0.143
Beer Tax	-2.102		-2.103	
Meat Price	-0.445	0.945	-0.438	0.627
Dairy Products Price	0.037	1.098	0.044	0.729
Fish and Seafood Price	-0.320	0.555	-1.478	0.369
Non-Alcoholic Beverages Price	0.114	1.014	-0.175	0.673
Household Energy and Utilities				
Electricity Price	-1.300	0.981	-1.290	0.665
Electricity Tax	**-1.946****		-1.933	
Electricity and Gas Price	-0.333	1.013	-0.323	0.687
Electricity and Gas Tax	2.104		2.117	
Petrol Price	-0.238	0.585	-0.230	0.397
Petrol Tax	-0.150		-0.141	
Other Commodity Groups				
Household Appliances Price	-2.504	1.670	-2.502	2.981
Clothing and Footwear Price	-1.384	0.921	-1.357	1.317

***, **, *: Significant at the 1%, 5% and 10% levels respectively

From Table 4a above, Sweden appears to be more responsive to tax changes as opposed to changes in producer price for each main commodity group[14]. Furthermore, the results for Sweden shows that taxation for the "Foodstuff" and "Household energy and utilities" commodity groups have a significant signaling effect. The implication is that taxation may have a larger effect than producer price in incentivizing sustained decreased consumption. Looking at individual commodities (Table 4b) we see a significant signaling effect from taxation on environmental taxation for electricity. For foodstuff commodities, none of the main commodities considered produce a significant signaling effect. Here it is suggested that the signaling effect is significant for more commodities which produce harmful public effects as only "Electricity" in "Household Energy and Utilities" has a significant result where overconsumption would lead to environmental problems which affect the public good.

Table 5a: Estimated own-price and expenditure elasticities – Denmark – Commodity Groups:

Main Commodity Groups	**Own-price**	**Expenditure**
Foodstuff Price	-0.961	0.614
Foodstuff Tax	-0.703	
Household Energy and Utilities Price	-1.054	0.506
Household Energy and Utilities Tax	-0.933	
Furnishings and Household Goods Price	-1.539	1.264
Apparel, Textiles and Maintenance Price	-1.928	0.803

***, **, *: Significant at the 1%, 5% and 10% levels respectively

[14] This contradicts findings made by Ghalwash (2007) where transportation has the opposite result.

Table 5b: Estimated own-price and expenditure elasticities – Denmark – Commodities:

Commodity	Own-price	Expenditure	Total own-price	Total Expenditure
Foodstuff				
Tobacco Price	-0.184	0.163	-0.184	0.100
Tobacco Tax	-0.280		-0.278	
Alcoholic Beverages Price	-0.542	-0.111	-0.542	-0.068
Alcoholic Beverages Tax	0.585		0.585	
Spirits and Wine Price	-0.624	0.622	-0.624	0.382
Spirits and Wine Tax	-0.550		-0.547	
Beer Price	-0.524	-0.169	-0.524	0.104
Beer Tax	0.613		0.613	
Meat Price	-0.386	0.174	-0.384	0.107
Dairy Products Price	-0.757	-0.072	-0.686	-0.044
Fish and Seafood Price	-1.289	0.409	-1.288	0.251
Non-Alcoholic Beverages Price	-0.269	-0.313	-0.270	-0.192
Household Energy and Utilities				
Electricity Price	-0.243	0.565	-0.243	0.286
Electricity Tax	**-1.896*****		-1.895	
Electricity and Gas Price	0.212	0.548	0.212	0.277
Electricity and Gas Tax	-0.345		-0.344	
Petrol Price	-0.194	0.665	-0.195	0.336
Petrol Tax	-0.453		-0.451	
Other Commodity Groups				
Household Appliances Price	-1.066	1.149	-1.072	1.452
Clothing and Footwear Price	-0.953	1.018	-1.003	0.817

***, **, *: Significant at the 1%, 5% and 10% levels respectively

The results (Table 5a) for Denmark none of the commodity groups possess a significant signaling effect despite consumers being more responsive to taxation than price for the "Household Energy and Utilities" commodity group. Overall for individual commodities (Table 5b), we can see that there is poor performance through taxation compared to producer price apart from tobacco, electricity and petrol. However, we do see that we have a significant signaling effect through only electricity taxation. However, we do not see significance in any health taxed commodities. Hence, policymakers cannot focus solely on taxation but increase education and legislation in order to reduce consumption of harmful commodities. Thus we can infer that taxation seems more efficient for commodities which produce harmful public effects.

Table 6a: Estimated own-price and expenditure elasticities – United Kingdom – Commodity Groups:

Main Commodity Groups	Own-price	Expenditure
Foodstuff Price	-0.906	0.643
Foodstuff Tax	-0.842	
Household Energy and Utilities Price	-0.740	0.734
Household Energy and Utilities Tax	-0.748	
Furnishings and Household Goods Price	-0.870	1.019
Apparel, Textiles and Maintenance Price	-0.991	0.819

***, **, *: Significant at the 1%, 5% and 10% levels respectively

Table 6b: Estimated own-price and expenditure elasticities – United Kingdom – Foodstuff:

Commodity	Own-price	Expenditure	Total own-price	Total Expenditure
Foodstuff				
Tobacco Price	-0.755	0.329	-0.755	0.212
Tobacco Tax	-0.836		-0.837	
Alcoholic Beverages Price	-1.055	0.635	-1.052	0.408
Alcoholic Beverages Tax	-2.005		-2.003	
Spirits and Wine Price	-1.060	0.135	-1.060	0.087
Spirits and Wine Tax	-1.375		-1.375	
Beer Price	-1.756	1.100	-1.755	0.707
Beer Tax	-2.100		-2.099	
Meat Price	-0.050	0.377	-0.464	0.242
Dairy Products Price	-0.162	0.278	-0.160	0.179
Fish and Seafood Price	-0.622	1.056	-0.621	0.679
Non-Alcoholic Beverages Price	-0.341	1.368	-0.338	0.880
Household Energy and Utilities				
Electricity Price	0.073	0.262	0.075	0.192
Electricity Tax	**-1.056*** **		-1.054	
Electricity and Gas Price	-0.014	0.358	-0.011	0.263
Electricity and Gas Tax	0.419		0.422	
Petrol Price	-0.344	0.353	-0.341	0.227
Petrol Tax	**-1.346** **		-1.343	
Other Commodity Groups				
Household Appliances Price	-1.123	0.409	-1.122	0.417
Clothing and Footwear Price	-0.768	0.673	-0.768	0.551

***, **, *: Significant at the 1%, 5% and 10% levels respectively

The results from the United Kingdom demonstrate a slight difference compared to the results from Sweden and Denmark. We see that the signaling effect is not significant for any of the commodity groups (Table 6a). For individual commodities (Table 6b), taxation seems to be more efficient though in tackling consumption of only electricity and petrol. This significance implies that taxation incentivizes reduced consumption more than producer price. From these results, we can see that the signalling effect seems more profound for tackling negative public effects through environmental taxation as opposed to negative private effects through health-based taxation. A distinct difference is that whilst Sweden and Denmark only saw significance

in “Electricity” taxation, for the UK we also see a significant result for “Petrol”. For electricity we also see a unique result where producer price seems to be virtually at a zero value which suggests that consumers are not aware of changes in producer price but well aware of that from taxation.

5. Conclusion

Overall, these results indicate that environmental policy through energy taxes is more effective in signalling negative public effects for consumption of electricity in all three countries and petrol in the UK. However, taxation seems less effective in signalling negative effects through consumption of tobacco and alcoholic beverages. This may imply that taxation is not as effective for private negative effects. Direct implications may be that the government may want to pursue increased legislation for commodities producing negative private effects. However despite these implications, this does not mean decision makers should abandon or decrease the amount of taxation where taxation still holds a signalling effect to at least a small degree and is a vital policy lever to fund added legislation and combating the negative effects from harmful commodities.

A potential improvement, subject to further research, would be a panel data study using micro data taking various household characteristics into account (i.e. region, age and income). This can be done using household budget surveys. Due to the scale of this study, I have focused on individual commodity analysis within the commodity group. Due to limitations of the data in producer price, it was not possible to split up electricity and gas taxation. Furthermore, the results presented here have shown whether or not the signalling effect is significant, but does not explain why there is a difference between different goods (apart from the public versus private nature of the good). Overall, “it is argued that what is needed is a comprehensive model on how tax attitudes come about” (Furnham, 1984, pg. 545). Specifically, this includes psychological determinant including political and macroeconomic variables.

Further improvements for future studies may be to include other factors that are omitted in this study. For example, the advancement of technology regarding motor vehicles and household appliances/connections, are factors that alter household consumption of petrol and household energy, respectively. Considering regulation and legislation, only those made by the government are considered. However, producers of harmful commodities also produce their own advertisements and campaigns to boost consumption. As stated by the ASPECT Consortium (2004), tobacco companies are a prime example where despite existing legislation, tobacco companies have launched their own promotion and campaigns to undermine and influence anti-tobacco legislation and to satisfy the “*psycho-social needs*” for current smokers. Likewise, the tobacco industry *“is increasingly aware of the need to target children and young adults to assure its future market”*. Future studies may include interaction variables regarding marketing campaigns by the tobacco industry.

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Appendix A

Figure 1: Household budget shares, Sweden

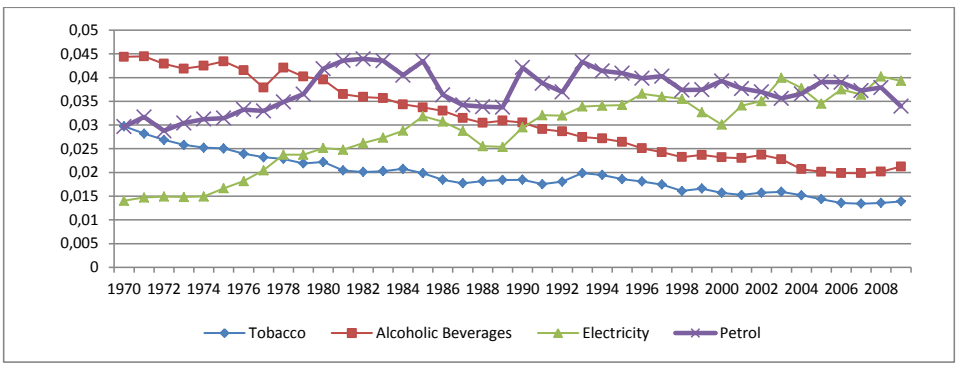


Figure 2: Household budget shares, Denmark

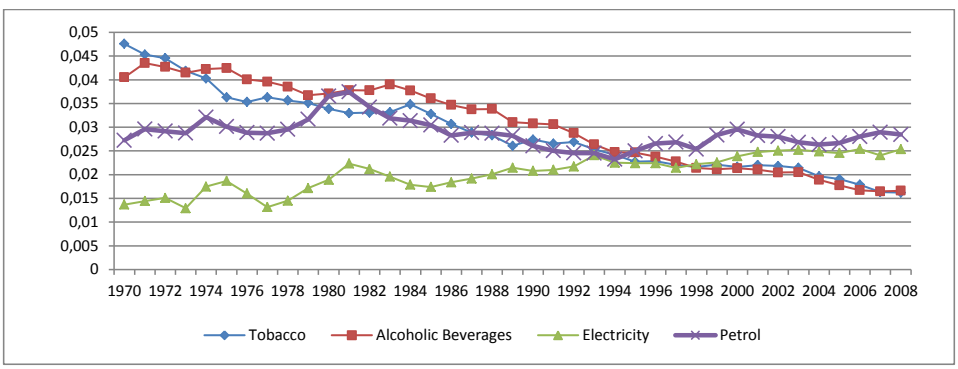
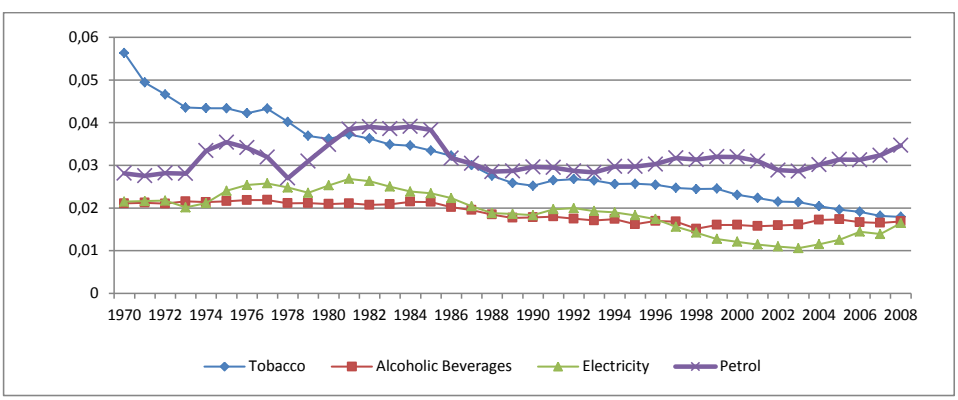


Figure 3: Household budget shares, United Kingdom



Appendix B

Table 1: Significant Tobacco Legislation - Sweden

Year	Details
1975	Information on health risks associated with tobacco use and information on harmful substances within tobacco must clearly be labelled (Act 1975:1154)
1989	Television without Frontiers Directive (89/552/EC)
1994	Tobacco Act - Enforcement of restrictions and bans on smoking in public places, product control, sales and trade regulations and advertising (Act 1993:581)
2002	Enforcement of Tobacco Products Directive (2001/37/EC) Further Ban on Smoking in Public Places - Amendment of Tobacco Act (Act 1993:581)
2004	Enforcement of Tobacco Advertising Directive (2003/33/EC)
2005	Re-enforcement of Tobacco Products Directive (2001/37/EC) for pictorial warnings
2006	Regulation of Smoking in Public Places

EU Directives: http://ec.europa.eu/health/tobacco/law/index_en.htm
Swedish Legislation Archive: http://www.notisum.se

Table 2: Significant Tobacco Legislation – Denmark:

Year	Details
1987	Legislation prohibiting marketing and advertising of tobacco (Act 1987:67)
1989	Television without Frontiers Directive (89/552/EC)
1991	Legislation demanding health warnings on tobacco products (Act 1991:817)
2002	Enforcement of the Tobacco Products Directive (2001/37/EC)
2003	Tobacco Advertising Directive (2003/33/EC)
2005	Re-enforcement of Tobacco Products Directive for pictorial warnings
2007	Smoke-free Environment Act (Act 2007:512) and Audiovisual Media Services Directive (2007/65/EC)

EU Directives: http://ec.europa.eu/health/tobacco/law/index_en.htm
Danish Legislation: https://www.retsinformation.dk/

Table 3: Significant Tobacco Legislation – United Kingdom:

Year	Details
1978	Advertising Ban - The Independent Broadcasting Authority publishes a Code of Advertising Standards deeming cigarettes and cigarette tobacco to be "unacceptable products" not to be advertised on commercial radio or TV (Act 1978:41)
1989	Television without Frontiers Directive (89/552/EEC) – Further extends the restrictions given by the Advertising Ban of 1978
1992	Enforcement of Children and Young Persons (Protection from Tobacco) - Increases penalties for underage sales of cigarettes, imposes requirements for general health and sales warning statements in retail premises and vending machines and prohibits sale of unpacked cigarettes (Act 1992:23)
1994	Enforcement of The Tobacco Products Labeling (Safety) Amendment Regulations Act (Act 1993:1947)
2002	Enforcement of Tobacco Products Directive (2001/37/EC)
2003	Enforcement of Tobacco Advertising and Promotion Act (Act 2002:2372)
2005	Re-enforcement of Tobacco Products Directive (2001/37/EC) for pictorial warnings
2006	Smoke-free (Premises and Enforcement) Regulations (Act 2006:3368)

2007	Audiovisual Media Services Directive (2007/65/EC)

UK Parliament Legislation Archive - http://www.legislation.gov.uk/
EU Directives: http://ec.europa.eu/health/tobacco/law/index_en.htm
http://data.euro.who.int/tobacco/Default.aspx?TabID=2404
http://www.ash.org.uk/current-policy-issues/advertising/tobacco-advertising

Table 4: Significant Alcohol Legislation - Sweden

Year	Details
1978	Legislation requiring advertisers to account for the health risks and special moderation of alcohol consumption (Act 1978:763)
1979	Legislation on prohibition of alcohol advertising and consumption in public places as well as advertisements of alcoholic products (KOVFS [Consumer Agency of Statutes] 1979:5/6)
1987	Alcoholic Strength Labeling (87/250/EEC)
1994	Swedish Directives: The Alcohol Act (1994:1738), Ordinance Containing Instructions for the Alcoholic Beverages Product Range Board (1994:2048) and Alcohol Ordinance (Act 1994:2046)
1996	Swedish Radio and TV Act – Legislation requiring tighter regulation regarding product placement for specific television and radio programs. Advertisements must also express moderation for alcohol use (Act 1996:844)
2000	Alcoholic Allergenic Effects Labeling (2000/13/EC).

EU Directives: http://europa.eu/legislation_summaries/consumers/index_en.htm
Swedish Legislation Archive: http://www.notisum.se

Table 5: Significant Alcohol Legislation – Denmark

Year	Details
1987	Alcoholic Strength Labeling (87/250/EEC)
1997	Broadcasting Act - Legislation prohibiting advertisements of alcohol with an alcoholic content of 2.8 pct. or more. For lower strength alcohol, advertisements should not be aimed at minors and must express moderation for alcohol use (Act 1997:489)
2000	Alcoholic Allergenic Effects Labeling (2000/13/EC)

EU Directives: http://europa.eu/legislation_summaries/consumers/index_en.htm
Danish Legislation: https://www.retsinformation.dk/

Table 6: Significant Alcohol Legislation – United Kingdom

Year	Details
1987	Alcoholic Strength Labeling (87/250/EEC)
1988	Control of Misleading Advertisements Regulations - Legislation on the content and messages within alcohol advertisements concerning benefits of alcohol consumption which may mislead the consumer (Act 1988:915)
2000	Alcoholic Allergenic Effects Labeling (2000/13/EC)
2003	Communications Act - Legislation prohibiting advertisements near to children's programming or aimed at minors. Advertisements must also express moderation for alcohol use (Act 2003:21)

EU Directives: http://europa.eu/legislation_summaries/consumers/index_en.htm
UK Parliament Legislation Archive - http://www.legislation.gov.uk/

Table 7: Significant Petrol Legislation – Sweden

Year	Details
1980	EC Directive requiring dealers of new cars to provide to customers free of charge a fuel economy guide in reducing CO_2 emissions along with a prominent listing of the 10 most fuel-efficient new cars ranked in order of CO_2 for each fuel type. Posters and labels must also reflect this (1980/1268/EC)

1992	Labeling Directive - EC Directive requiring all motor vehicles sold or rented to include within listing the CO2 emissions in grams per km travelled (1992/75/EC)
1999	EC Directive requiring dealers of new cars to include in each car and in the selling location, free of charge, the official fuel consumption and CO2 emission figures of that vehicle in order to help consumers choose vehicles with low fuel consumption (1999/94/EC)
2003	Legislation requiring the promotion and clear sale of at least one renewable fuel at a location where fuel is sold (Act 2005:1248)

European Legislative Archive: http://eur-lex.europa.eu/en/index.htm
Swedish Legislation Archive: http://www.notisum.se

Table 8: Significant Petrol Legislation – Denmark

Year	Details
1980	EC Directive requiring dealers of new cars to provide to customers free of charge a fuel economy guide in reducing CO2 emissions along with a prominent listing of the 10 most fuel-efficient new cars ranked in order of CO2 for each fuel type. Posters and labels must also reflect this (1980/1268/EC)
1992	Labelling Directive - EC Directive requiring all motor vehicles sold or rented to include within listing the CO2 emissions in grams per km travelled (1992/75/EC)
1999	EC Directive requiring dealers of new cars to include in each car and in the selling location, free of charge, the official fuel consumption and CO2 emission figures of that vehicle in order to help consumers choose vehicles with low fuel consumption (1999/94/EC)

European Legislative Archive: http://eur-lex.europa.eu/en/index.htm
Danish Legislation: https://www.retsinformation.dk/

Table 9: Significant Petrol Legislation – United Kingdom

Year	Details
1980	EC Directive requiring dealers of new cars to provide to customers free of charge a fuel economy guide in reducing CO2 emissions along with a prominent listing of the 10 most fuel-efficient new cars ranked in order of CO2 for each fuel type. Posters and labels must also reflect this (1980/1268/EC)
1992	Labelling Directive - EC Directive requiring all motor vehicles sold or rented to include within listing the CO2 emissions in grams per km travelled (1992/75/EC)
1993	Clean Air Act - Legislation requiring local authorities to arrange and promote investigation and research to the problem of air pollution through promotional material (Act 1993:11)
1999	EC Directive requiring dealers of new cars to include in each car and in the selling location, free of charge, the official fuel consumption and CO2 emission figures of that vehicle in order to help consumers choose vehicles with low fuel consumption (1999/94/EC)
2001	Passenger Car (Fuel Consumption and CO2 Emissions Information) Regulations - Legislation for dealers of new cars to include in each car and in the selling location, free of charge, the official fuel consumption and CO2 emission figures of that vehicle (Act 2001:3523)

European Legislative Archive: http://eur-lex.europa.eu/en/index.htm
UK Parliament Legislation Archive - http://www.legislation.gov.uk/

Table 10: Significant Household Energy Legislation – Sweden

Year	Details
1992	Energy Labeling Directive - Legislation requiring major appliances and light bulbs to have energy labels including an energy class given by a colour code giving a scale of an appliances electrical consumption as well as the specific values of consumption, efficiency and capacity of energy by appliance type (80/1268/EC)
2006	Energy Provision of Buildings Act - Provision of energy reports from local councils on the energy efficiency and usage of households with recommendations for improvement (Act 2006:985)

2007	Ordinance on Grants for Municipal Energy and Climate Advice (SFS 1997:1322)
2008	Transparency of gas and electricity prices - EC Directive requiring electricity prices to include clearly how much is taken as part of an energy surtax (2008/92/EC)

European Legislative Archive: http://eur-lex.europa.eu/en/index.htm
Swedish Legislation Archive: http://www.notisum.se

Table 11: Significant Household Energy Legislation – Denmark

Year	Details
1992	Energy Labeling Directive - Legislation requiring major appliances and light bulbs to have energy labels including an energy class given by a colour code giving a scale of an appliances electrical consumption as well as the specific values of consumption, efficiency and capacity of energy by appliance type (80/1268/EC)
1999	Act on the Promotion of Savings in Energy Consumption - Legislation requiring energy consumption of households to be available along with promotion and advice on how to minimize energy consumption for individual households (Act 1999:241)
2004	Act to Promote Energy Saving in Buildings - Promotion on energy saving methods for households to be subsidized and distributed nationally (Act 2004:136)
2008	Transparency of gas and electricity prices - EC Directive requiring electricity prices to include clearly how much is taken as part of an energy surtax (2008/92/EC)

European Legislative Archive: http://eur-lex.europa.eu/en/index.htm
Danish Legislation: https://www.retsinformation.dk/

Table 12: Significant Household Energy Legislation – United Kingdom

Year	Details
1992	Energy Labeling Directive - Legislation requiring major appliances and light bulbs to have energy labels including an energy class given by a colour code giving a scale of an appliances electrical consumption as well as the specific values of consumption, efficiency and capacity of energy by appliance type (80/1268/EC)
2007	The Energy Performance of Buildings (Certificates and Inspections) Regulations - Provision of energy reports from local councils on the energy efficiency and usage of households with recommendations for improvement (Act 2007:991)
2008	Transparency of gas and electricity prices - EC Directive requiring electricity prices to include clearly how much is taken as part of an energy surtax (2008/92/EC)

European Legislative Archive: http://eur-lex.europa.eu/en/index.htm
UK Parliament Legislation Archive - http://www.legislation.gov.uk/

Appendix C

Table 1: Demand System Parameter Estimates for the Main Commodity Groups – Sweden:

	Foodstuff	Household Energy and Utilities	Furnishings and Household Goods	Apparel, Textiles and Maintenance
Constant	0.2970 (8.21)	0.1001 (3.95)	0.1589 (4.30)	0.1344 (4.59)
Foodstuff Price	0.0552 (3.78)	0.0119 (0.57)	0.0009 (0.06)	0.0090 (0.56)
Foodstuff Tax	-0.0012 (-0.11)	0.0209 (1.16)	0.0105 (1.00)	-0.0392 (-3.05)
Household Energy and Utilities Price	-0.0010 (-0.17)	0.0119 (2.54)	-0.0116 (-1.96)	-0.0205 (-1.88)

Household Energy and Utilities Tax	-0.0090 (-1.29)	0.0851 (3.15)	-0.0259 (-3.74)	-0.0392 (-3.05)
Furnishings and Household Goods Price	-0.0516 (-2.76)	0.2931 (0.88)	0.0200 (1.10)	0.0126 (0.60)
Apparel, Textiles and Maintenance Price	0.0429 (1.71)	0.0025 (0.10)	-0.0681 (-2.74)	-0.0278 (-1.26)
Expenditure	-0.0659 (-15.24)	-0.0183 (-1.11)	0.0372 (4.29)	0.0191 (-1.89)

Table 2a: Demand System Parameter Estimates for the Foodstuff Subgroup – Sweden:

	Tobacco	**Alcoholic Beverages**	**Spirits and Wine**	**Beer**
Constant	0.0323 (3.44)	0.0802 (5.51)	0.0783 (8.84)	0.0172 (3.85)
Tobacco Price	-0.0010 (-0.31)	0.0011 (0.23)	0.0060 (1.31)	-0.0049 (-2.10)
Tobacco Tax	-0.0040 (-0.72)	0.0057 (1.25)	0.0042 (1.55)	-0.0015 (-1.02)
Alcoholic Beverages Price	0.0100 (1.55)	0.0031 (0.40)	N/A	N/A
Alcoholic Beverages Tax	-0.0072 (-1.07)	-0.0163 (-1.28)	N/A	N/A
Spirits and Wine Price	N/A	N/A	-0.0129 (-2.62)	-0.0024 (-0.48)
Spirits and Wine Tax	N/A	N/A	-0.0141 (-1.78)	-0.0004 (-0.008)
Beer Price	N/A	N/A	0.0095 (1.77)	0.0102 (2.73)
Beer Tax	N/A	N/A	0.0144 (1.60)	-0.0036 (-0.43)
Meat Price	0.0187 (4.39)	0.0138 (1.54)	0.0088 (1.31)	0.0016 (0.57)
Dairy Products Price	-0.0020 (-0.45)	-0.0133 (-1.30)	-0.0175 (-3.14)	0.0029 (0.67)
Fish and Seafood Price	-0.0028 (-0.40)	-0.0043 (-0.42)	-0.0023 (-0.35)	-0.0073 (-1.63)
Non-Alcoholic Beverages Price	0.0041 (1.78)	0.0011 (0.29)	0.0042 (1.29)	0.0048 (1.69)
Expenditure	-0.0285 (-2.43)	-0.0097 (-0.73)	-0.0057 (-0.72)	-0.0064 (-1.10)
Legislation 1 Int. Term 1	0.0016 (1.06) 0.0111 (1.39)	0.0036 (2.36) (omitted)	0.0019 (2.22) (omitted)	0.0003 (0.90) (omitted)
Legislation 2 Int. Term 2	0.0013 (0.51) 0.0205 (1.10)	-0.0041 (-0.96) -0.0069 (-0.41)	-0.0027 (-0.86) 0.0232 (1.56)	0.0007 (0.77) 0.0074 (1.22)
Legislation 3 Int. Term 3	-0.0063 (-5.36) -0.0278 (-6.32)	0.0067 (1.85) 0.0424 (1.46)	0.0044 (1.44) 0.0233 (1.56)	-0.0016 (-1.21) -0.0524 (-2.57)
Legislation 4 Int. Term 4	-0.0088 (-0.67) -0.0273 (-0.67)	-0.0918 (-1.15) -0.3041 (-1.16)	-0.0073 (-0.39) -0.0180 (-0.44)	0.0156 (3.90) 0.1136 (3.97)
Legislation 5 Int. Term 5	0.0175 (1.07) 0.0530 (1.14)	0.0947 (1.13) 0.3087 (1.15)	0.0165 (0.55) 0.0372 (0.58)	-0.0082 (-2.95) -0.0624 (-3.21)
Legislation 6 Int. Term 6	0.0006 (0.59) (omitted)	-0.0095 (-1.36) -0.0289 (-1.35)	-0.0188 (-1.20) -0.0429 (-1.25)	-0.0024 (-0.78) -0.0117 (-0.95)
Legislation 7 Int. Term 7	0.0009 (1.39) (omitted)			

Int. Term m = Interaction Term for legislation m; N/A = Not Applicable

Table 2b: Demand System Parameter Estimates for the Foodstuff Subgroup – Sweden:

	Meat	**Dairy Products**	**Fish and Seafood**	**Non-Alcoholic Beverages**
Constant	0.0762 (22.09)	0.0434 (7.39)	0.0196 (13.10)	0.0315 (10.79)
Tobacco Price	0.0013 (0.85)	-0.0048 (-3.24)	-0.0003 (-0.48)	0.0035 (3.37)
Tobacco Tax	-0.0002 (-0.13)	-0.0017 (-0.86)	-0.0007 (-0.69)	0.0028 (2.10)
Alcoholic Beverages Price	-0.0182 (-6.88)	-0.0268 (-9.09)	-0.0083 (-6.24)	-0.0151 (-9.09)
Alcoholic Beverages Tax	-0.0168 (-3.44)	-0.0233 (-4.71)	-0.0068 (-2.84)	-0.0111 (-2.92)
Spirits and Wine Price	N/A	N/A	N/A	N/A
Spirits and Wine Tax	N/A	N/A	N/A	N/A
Beer Price	N/A	N/A	N/A	N/A
Beer Tax	N/A	N/A	N/A	N/A
Meat Price	0.0146 (3.74)	0.0057 (1.31)	0.0050 (2.47)	0.0040 (1.36)
Dairy Products Price	-0.0067 (-1.75)	0.0259 (6.71)	-0.0025 (-1.34)	-0.0085 (-2.90)
Fish and Seafood Price	0.0032 (1.18)	-0.0078 (-1.58)	0.0058 (2.95)	-0.0031 (-0.91)
Non-Alcoholic Beverages Price	-0.0008 (-0.58)	0.0034 (1.35)	0.0021 (2.89)	0.0166 (13.44)
Expenditure	-0.0014 (-0.37)	0.0024 (0.43)	-0.0038 (-1.80)	0.0002 (0.05)

N/A = Not Applicable

Table 3: Demand System Parameter Estimates for the Household Energy and Utilities Subgroup – Sweden:

	Electricity	**Electricity and Gas**	**Petrol**
Constant	-0.0202 (-3.00)	-0.0251 (-3.97)	-0.0029 (0.03)
Electricity Price	-0.0079 (-0.94)	N/A	N/A
Electricity Tax	-0.0269 (-2.56)	N/A	N/A
Electricity and Gas Price	N/A	0.0179 (4.58)	-0.0055 (-0.77)
Electricity and Gas Tax	N/A	0.0179 (3.14)	-0.0038 (-0.49)
Petrol Price	0.0160 (1.95)	-0.0094 (-1.70)	-0.0055 (-0.77)
Petrol Tax	0.0217 (2.44)	-0.0139 (-2.57)	-0.0038 (-0.49)
Expenditure	-0.0005 (-0.16)	0.0003 (0.08)	-0.0152 (-2.25)
Legislation 1	0.0046 (1.96)	-0.0022 (-1.36)	0.0059 (0.62)
Int. Term 1	0.0063 (1.01)	-0.0041 (-2.97)	0.0024 (0.30)
Legislation 2	-0.0034 (2.02)	-0.0040 (-2.58)	-0.0002 (-0.10)
Int. Term 2	(omitted)	(omitted)	-0.0063 (-1.03)
Legislation 3	-0.0016 (-0.74)	0.0061 (3.85)	0.0018 (0.91)
Int. Term 3	-0.0041 (-0.57)	0.0835 (4.30)	0.0149 (2.08)
Legislation 4	0.0004 (0.31)	0.0042 (5.28)	0.0001 (0.07)
Int. Term 4	(omitted)	(omitted)	-0.0002 (-0.08)

Int. Term m = Interaction Term for legislation m; N/A = Not Applicable

Table 4: Demand System Parameter Estimates for the Other Commodities Subgroup – Sweden:

	Household Appliances	**Clothing and Footwear**
Constant	-0.0050 (-1.60)	-0.0410 (-0.85)
Household Appliances Price	-0.0060 (-3.22)	-0.1042 (-7.36)
Household Appliances Tax	-0.0003 (0.12)	-0.0724 (-3.93)
Clothing and Footwear Price	0.0056 (2.41)	0.1328 (5.44)
Clothing and Footwear Tax	0.0068 (3.24)	0.1078 (5.38)
Expenditure	0.0027 (8.03)	-0.0044 (-0.67)

Table 5: Demand System Parameter Estimates for the Main Commodity Groups – Denmark:

	Foodstuff	**Household Energy and Utilities**	**Furnishings and Household Goods**	**Apparel, Textiles and Maintenance**
Constant	0.2699 (15.56)	-0.1710 (-6.78)	0.2389 (15.15)	0.1525 (9.50)
Foodstuff Price	0.0386 (2.67)	0.0109 (0.48)	0.0175 (1.75)	0.0014 (0.08)
Foodstuff Tax	0.0223 (2.47)	0.0217 (1.24)	0.0085 (1.41)	0.0049 (0.41)
Household Energy and Utilities Price	-0.105 (-1.61)	-0.0093 (-1.19)	-0.0013 (-0.26)	-0.0097 (-1.75)
Household Energy and Utilities Tax	0.0020 (0.28)	0.0458 (3.51)	-0.0027 (-0.61)	-0.0052 (-0.70)
Furnishings and Household Goods Price	0.0363 (1.38)	0.0782 (2.62)	-0.0328 (-1.99)	0.0526 (1.86)
Apparel, Textiles and Maintenance Price	0.0017 (0.13)	0.0607 (2.61)	-0.0315 (-3.41)	0.526 (1.86)
Expenditure	-0.0877 (-53.26)	-0.0826 (-11.05)	0.0166 (4.35)	-0.0107 (-2.40)

Table 6a: Demand System Parameter Estimates for the Foodstuff Subgroup – Denmark:

	Tobacco	**Alcoholic Beverages**	**Spirits and Wine**	**Beer**
Constant	0.0514 (3.16)	0.0364 (2.33)	-0.0017 (-0.24)	0.0444 (4.62)
Tobacco Price	0.0209 (2.62)	-0.0024 (-0.41)	0.0072 (1.52)	-0.0111 (-2.44)
Tobacco Tax	0.0189 (1.82)	-0.0078 (1.11)	0.0016 (0.24)	-0.0106 (-2.39)
Alcoholic Beverages Price	-0.0047 (-0.45)	0.0117 (1.43)	N/A	N/A
Alcoholic Beverages Tax	0.0089 (0.98)	0.0077 (0.95)	N/A	N/A
Spirits and Wine Price	N/A	N/A	0.0052 (0.64)	0.0009 (0.13)
Spirits and Wine Tax	N/A	N/A	-0.0004 (-0.05)	0.0093 (2.18)
Beer Price	N/A	N/A	-0.0013 (-0.30)	0.0058 (1.51)

Beer Tax	N/A	N/A	0.0002 (0.03)	0.0012 (0.24)
Meat Price	0.0116 (1.01)	-0.0051 (-0.51)	0.0014 (0.24)	-0.0050 (-0.98)
Dairy Products Price	-0.0006 (-0.05)	0.0180 (2.16)	0.0057 (1.23)	0.0016 (0.29)
Fish and Seafood Price	-0.0082 (-0.64)	0.0093 (1.00)	-0.0074 (-1.39)	0.0204 (2.40)
Non-Alcoholic Beverages Price	0.0010 (0.60)	-0.0012 (-0.73)	-0.0016 (-1.33)	-0.0026 (-2.14)
Expenditure	-0.0221 (-2.43)	-0.0304 (-3.33)	-0.0053 (-0.84)	-0.0147 (-1.95)
Legislation 1	-0.0100 (-2.26)	-0.0013 (-0.60)	0.0037 (2.07)	-0.0024 (-2.54)
Int. Term 1	-0.0578 (-1.49)	0.0107 (0.99)	0.0275 (2.57)	-0.0053 (-0.84)
Legislation 2	0.0014 (0.16)	0.0204 (0.85)	-0.0161 (-0.99)	0.0164 (3.27)
Int. Term 2	0.0182 (0.34)	0.0673 (0.97)	-0.0356 (-0.92)	0.0527 (3.60)
Legislation 3	0.0095 (2.14)	-0.0159 (-0.70)	0.0068 (0.41)	-0.0102 (-2.62)
Int. Term 3	0.0556 (2.48)	-0.0433 (-0.68)	0.0148 (0.38)	-0.0284 (-2.59)
Legislation 4	-0.0032 (-0.42)			
Int. Term 4	-0.0113 (-0.68)			
Legislation 5	0.0004 (0.57)			
Int. Term 5	(omitted)			
Legislation 6	-0.0371 (-1.14)			
Int. Term 6	-0.0733 (-1.08)			
Legislation 7	0.0329 (0.86)			
Int. Term 7	0.0680 (0.84)			

Int. Term m = Interaction Term for legislation m; N/A = Not Applicable

Table 6b: Demand System Parameter Estimates for the Foodstuff Subgroup – Denmark:

	Meat	**Dairy Products**	**Fish and Seafood**	**Non-Alcoholic Beverages**
Constant	0.0939 (8.94)	0.0279 (2.92)	0.0104 (2.71)	0.0321 (3.58)
Tobacco Price	-0.0140 (-2.05)	-0.0091 (-1.66)	-0.0030 (-1.45)	-0.0028 (-0.46)
Tobacco Tax	-0.0016 (-0.24)	-0.0058 (-1.23)	-0.0022 (-1.10)	-0.0031 (-0.49)
Alcoholic Beverages Price	-0.0046 (-0.59)	0.0037 (0.69)	0.0085 (4.00)	0.0006 (0.08)
Alcoholic Beverages Tax	-0.0117 (-2.57)	0.0012 (0.49)	0.0069 (5.23)	-0.0007 (-0.14)
Spirits and Wine Price	N/A	N/A	N/A	N/A
Spirits and Wine Tax	N/A	N/A	N/A	N/A
Beer Price	N/A	N/A	N/A	N/A
Beer Tax	N/A	N/A	N/A	N/A
Meat Price	0.0192 (2.99)	0.0116 (2.53)	-0.0036 (-1.83)	0.0227 (4.48)
Dairy Products Price	0.0146 (1.82)	0.0037 (1.00)	0.0032 (0.98)	-0.0061 (-0.85)
Fish and Seafood Price	-0.0004 (-0.07)	0.0040 (1.00)	-0.0018 (-0.93)	-0.0070 (-1.44)
Non-Alcoholic Beverages Price	0.0008 (0.46)	0.0014 (1.72)	0.0009 (1.51)	0.0117 (12.46)
Expenditure	-0.0270 (-3.02)	-0.0174 (-2.56)	-0.0036 (-1.02)	-0.0217 (-2.54)

N/A = Not Applicable

Table 7: Demand System Parameter Estimates for the Household Energy and Utilities Subgroup – Denmark:

	Electricity	**Electricity and Gas**	**Petrol**
Constant	-0.0020 (-0.82)	0.0049 (1.43)	0.0452 (6.53)
Electricity Price	0.0148 (4.52)	N/A	N/A
Electricity Tax	0.0092 (2.45)	N/A	N/A
Electricity and Gas Price	N/A	0.0289 (3.85)	-0.0171 (-3.57)
Electricity and Gas Tax	N/A	0.0153 (3.26)	-0.0042 (-0.96)
Petrol Price	-0.0025 (-1.06)	-0.0152 (-2.19)	0.0226 (4.50)
Petrol Tax	-0.0029 (-0.94)	-0.0044 (-0.95)	0.0190 (5.38)
Expenditure	-0.0086 (-3.40)	-0.109 (-3.29)	-0.0095 (-4.33)
Legislation 1	0.0005 (0.12)	0.0001 (0.03)	0.0052 (2.42)
Int. Term 1	-0.0049 (-0.38)	-0.0414 (-2.64)	-0.0070 (-1.90)
Legislation 2	0.0002 (0.31)	0.0024 (0.67)	-0.0068 (-3.96)
Int. Term 2	(omitted)	0.0210 (0.85)	0.0186 (5.05)
Legislation 3	-0.0055 (-1.02)	0.0057 (1.51)	0.0098 (4.94)
Int. Term 3	-0.0221 (-1.19)	0.0205 (1.00)	-0.0153 (-3.51)
Legislation 4	-0.0018 (-1.50)	-0.0007 (-0.64)	
Int. Term 4	(omitted)	(omitted)	

Int. Term m = Interaction Term for legislation m; N/A = Not Applicable

Table 8: Demand System Parameter Estimates for the Other Commodities Subgroup – Denmark:

	Household Appliances	**Clothing and Footwear**
Constant	0.0278 (13.64)	0.1173 (12.86)
Household Appliances Price	-0.0006 (-0.24)	-0.0147 (-1.06)
Household Appliances Tax	0.0027 (2.44)	0.0083 (0.89)
Clothing and Footwear Price	-0.0041 (-1.72)	0.0025 (0.23)
Clothing and Footwear Tax	-0.0040 (-2.42)	0.0084 (1.12)
Expenditure	0.0015 (2.00)	0.0010 (0.13)

Table 9: Demand System Parameter Estimates for the Main Commodity Groups – United Kingdom:

	Foodstuff	**Household Energy and Utilities**	**Furnishings and Household Goods**	**Apparel, Textiles and Maintenance**
Constant	0.3333 (15.63)	0.2521 (14.30)	0.0504 (7.94)	0.1401 (17.59)
Foodstuff Price	0.0056 (0.46)	0.0467 (4.45)	-0.0162 (-3.32)	0.0170 (3.15)
Foodstuff Tax	0.0166 (1.97)	0.0010 (0.14)	-0.0019 (-0.60)	-0.0003 (-0.10)
Household Energy and Utilities Price	0.0135 (0.87)	0.0420 (3.57)	-0.0063 (-1.05)	-0.0357 (-4.54)
Household Energy and Utilities Tax	0.0091 (0.49)	0.0404 (2.62)	0.0062 (0.85)	-0.0394 (-3.92)
Furnishings and Household Goods Price	-0.0146 (-1.36)	-0.0074 (-0.42)	0.0082 (1.10)	0.0203 (2.27)
Apparel, Textiles and Maintenance Price	0.0285 (5.13)	-0.0489 (-3.78)	0.0178 (3.33)	-0.0002 (-0.03)
Expenditure	-0.0614 (-22.46)	-0.0543 (-13.03)	0.0012 (0.31)	-0.0120 (-4.48)

Table 10a: Demand System Parameter Estimates for the Foodstuff Subgroup – United Kingdom:

	Tobacco	**Alcoholic Beverages**	**Spirits and Wine**	**Beer**
Constant	0.1756 (2.01)	0.0400 (3.10)	0.0329 (2.08)	0.0038 (0.80)
Tobacco Price	0.0058 (0.64)	0.0024 (0.85)	0.0023 (0.89)	-0.0009 (-1.16)
Tobacco Tax	0.0754 (1.21)	0.0019 (0.55)	0.0015 (0.38)	-0.0002 (-0.20)
Alcoholic Beverages Price	0.0099 (0.66)	-0.0011 (-0.23)	N/A	N/A
Alcoholic Beverages Tax	0.0109 (0.53)	0.0011 (0.20)	N/A	N/A
Spirits and Wine Price	N/A	N/A	-0.0009 (-0.06)	0.0061 (1.36)
Spirits and Wine Tax	N/A	N/A	-0.0027 (-0.23)	0.0038 (1.01)
Beer Price	N/A	N/A	0.0016 (0.15)	-0.0038 (-1.29)
Beer Tax	N/A	N/A	0.0032 (0.37)	-0.0024 (-1.06)
Meat Price	-0.0010 (-0.05)	-0.0037 (-0.43)	-0.0051 (-0.61)	-0.0008 (-0.37)
Dairy Products Price	0.0111 (0.85)	0.0075 (1.06)	0.0088 (1.29)	-0.0011 (-0.53)
Fish and Seafood Price	-0.0087 (-0.89)	-0.0036 (-0.71)	0.0004 (0.07)	-0.0004 (-0.24)
Non-Alcoholic Beverages Price	-0.0006 (-0.03)	0.0010 (0.23)	0.0003 (0.08)	0.0009 (0.83)
Expenditure	-0.0373 (-3.24)	-0.0067 (-0.97)	-0.0114 (-1.28)	0.0005 (0.20)
Legislation 1	-0.0165 (-1.32)	-0.0008 (-1.85)	-0.0002 (-0.33)	0.0001 (0.32)

Int. Term 1	-0.0693 (-1.18)	(omitted)	-0.0015 (-0.39)	-0.0007 (-1.01)
Legislation 2	-0.0175 (-2.01)	5.24e-06 (0.00)	-0.0010 (-1.51)	-0.0004 (-1.59)
Int. Term 2	0.0367 (1.93)	-0.0038 (-1.52)	(omitted)	(omitted)
Legislation 3	0.0361 (2.04)	-0.0248 (-1.29)	-0.0087 (-2.28)	0.0425 (1.64)
Int. Term 3	-0.0593 (-2.06)	0.0341 (1.29)	0.0229 (2.31)	-0.0447 (-1.64)
Legislation 4	-0.0202 (-2.08)	0.0405 (1.48)	0.0127 (1.31)	-0.0405 (-1.56)
Int. Term 4	0.0254 (1.92)	-0.0497 (-1.41)	-0.0238 (-1.27)	0.0424 (1.57)
Legislation 5	(omitted)			
Int. Term 5	-0.0008 (-0.70)			
Legislation 6	0.2487 (0.38)			
Int. Term 6	-0.1879 (-0.38)			
Legislation 7	-0.2419 (-0.37)			
Int. Term 7	0.1826 (0.37)			
Legislation 8	(omitted)			
Int. Term 8	0.0007 (1.24)			
Legislation 9	(omitted)			
Int. Term 9	0.0002 (0.28)			

Int. Term m = Interaction Term for legislation m; N/A = Not Applicable

Table 10b: Demand System Parameter Estimates for the Foodstuff Subgroup – United Kingdom:

	Meat	**Dairy Products**	**Fish and Seafood**	**Non-Alcoholic Beverages**
Constant	0.1073 (6.73)	0.0445 (3.05)	0.0072 (3.62)	-0.0065 (-1.22)
Tobacco Price	0.0044 (0.91)	0.0051 (1.41)	0.00001 (0.04)	0.0010 (1.01)
Tobacco Tax	0.0095 (3.02)	0.0056 (2.14)	-0.0010 (-2.83)	-0.0014 (-1.70)
Alcoholic Beverages Price	-0.0352 (-4.47)	-0.0207 (-3.11)	-0.0002 (-0.25)	-0.0099 (-3.45)
Alcoholic Beverages Tax	-0.0327 (-3.96)	0.0047 (1.05)	-0.0009 (-1.18)	-0.0110 (-3.07)
Spirits and Wine Price	N/A	N/A	N/A	N/A
Spirits and Wine Tax	N/A	N/A	N/A	N/A
Beer Price	N/A	N/A	N/A	N/A
Beer Tax	N/A	N/A	N/A	N/A
Meat Price	0.0267 (2.49)	0.0128 (1.86)	-0.0015 (-1.33)	0.0068 (2.72)
Dairy Products Price	0.0152 (2.06)	0.0138 (2.44)	-0.0005 (-0.53)	-0.0099 (-4.40)
Fish and Seafood Price	-0.0024 (-0.47)	-0.0016 (-0.46)	0.0017 (2.41)	0.0031 (2.02)
Non-Alcoholic Beverages Price	-0.0057 (-0.96)	-0.0032 (-0.69)	-0.0001 (-0.24)	0.0082 (3.31)
Expenditure	-0.0179 (-1.93)	-0.0121 (-1.66)	0.0002 (0.18)	0.0045 (1.28)

N/A = Not Applicable

Table 11: Demand System Parameter Estimates for the Household Energy and Utilities Subgroup – United Kingdom:

	Electricity	**Electricity and Gas**	**Petrol**
Constant	0.0325 (5.82)	0.0363 (7.02)	0.0038 (0.26)
Electricity Price	0.0189 (14.62)	N/A	N/A
Electricity Tax	0.0198 (4.22)	N/A	N/A
Electricity and Gas Price	N/A	0.0307 (17.69)	0.0049 (1.26)
Electricity and Gas Tax	N/A	0.0322 (14.02)	0.0220 (3.22)
Petrol Price	-0.0082 (-3.66)	-0.0114 (-2.66)	0.0199 (2.86)
Petrol Tax	-0.0138 (-4.95)	-0.0217 (-4.69)	-0.0041 (-0.20)
Expenditure	-0.0131 (-13.50)	-0.0204 (-9.70)	-0.0203 (-4.21)
Legislation 1	0.0007 (0.31)	0.0036 (2.79	-2.39e-06
Int. Term 1	0.0039 (0.71)	-0.0041 (-1.15)	0.0038 (0.25)
Legislation 2	0.0092 (5.12)	-0.0017 (-1.81)	0.0028 (2.61)
Int. Term 2	-0.0250 (-5.37)	0.0164 (4.72)	(omitted)
Legislation 3	-0.0012 (-2.85)	0.0019 (9.54)	0.0014 (0.69)
Int. Term 3	(omitted)	(omitted)	0.0156 (0.81)
Legislation 4			0.0039 (1.42)
Int. Term 4			0.0052 (0.29)
Legislation 5			-0.0086 (-2.63)
Int. Term 5			-0.0320 (-2.97)

Int. Term m = Interaction Term for legislation m; N/A = Not Applicable

Table 12: Demand System Parameter Estimates for the Other Commodities Subgroup – United Kingdom:

	Household Appliances	**Clothing and Footwear**
Constant	0.0038 (0.64)	0.1435 (15.86)
Household Appliances Price	-0.0014 (-0.47)	-0.0057 (-0.70)
Household Appliances Tax	-0.0027 (-0.59)	-0.0196 (-2.16)
Clothing and Footwear Price	0.0101 (2.15)	0.0136 (1.51)
Clothing and Footwear Tax	0.0018 (0.50)	-0.0032 (-0.50)
Expenditure	-0.0064 (-4.34)	-0.0212 (-5.39)

Appendix D

Table 1: F-Test for Parameter Equality – Sweden:

Commodity	**F-test**	**Null Hypothesis: $\gamma_{ij} \geq \overline{\gamma}_{ij}$**	**Null Hypothesis: $\gamma_{ij} \leq \overline{\gamma}_{ij}$**
Tobacco	0.27	Do not reject (0.69532363)	Do not reject (0.30467637)
Alcoholic Beverages	2.26	Reject* (0.07680724)	Do not reject (0.92319276)
Beer	3.25	Reject** (0.0473398)	Do not reject (0.9526602)
Spirits and Wine	0.02	Do not reject (0.44096079)	Do not reject (0.55903921)
Electricity	14.31	Reject*** (0.00037496)	Do not reject (0.99962504)
Electricity and Gas	0.00	Do not reject (0.50201427)	Do not reject (0.49798573)
Petrol	2.49	Do not reject (0.93664629)	Reject* (0.06335371)

***, **, *: Significant at the 1%, 5% and 10% levels respectively

Table 2: F-Test for Parameter Equality – Denmark:

Commodity	**F-test**	**Null Hypothesis: $\gamma_{ij} \geq \overline{\gamma}_{ij}$**	**Null Hypothesis: $\gamma_{ij} \leq \overline{\gamma}_{ij}$**
Tobacco	0.05	Do not reject (0.41298259)	Do not reject (0.58701741)
Alcoholic Beverages	0.61	Do not reject (0.7772721)	Do not reject (0.2227279)
Beer	4.53	Do not reject (0.97634588)	Reject** (0.02365412)
Spirits and Wine	1.32	Do not reject (0.86725234)	Do not reject (0.13274766)
Electricity	2.52	Reject* (0.06167522)	Do not reject (0.93832478)
Electricity and Gas	2.49	Reject* (0.06328476)	Do not reject (0.93671524)
Petrol	0.46	Do not reject (0.2513392)	Do not reject (0.7486608)

***, **, *: Significant at the 1%, 5% and 10% levels respectively

Table 3: F-Test for Parameter Equality – United Kingdom:

Commodity	**F-test**	**Null Hypothesis: $\gamma_{ij} \geq \overline{\gamma}_{ij}$**	**Null Hypothesis: $\gamma_{ij} \leq \overline{\gamma}_{ij}$**
Tobacco	1.57	Do not reject (0.12541151)	Do not reject (0.87458849)
Alcoholic Beverages	0.42	Do not reject (0.2631611)	Do not reject (0.7368389)
Beer	2.37	Reject* (0.07398097)	Do not reject (0.92601903)
Spirits and Wine	0.10	Do not reject (0.38089703)	Do not reject (0.61910297)
Electricity	0.04	Do not reject (0.42603413)	Do not reject (0.57396587)
Electricity and Gas	0.42	Do not reject (0.74001396)	Do not reject (0.25998604)
Petrol	2.06	Reject* (0.08155793)	Do not reject (0.91844207)

***, **, *: Significant at the 1%, 5% and 10% levels respectively

II

Signaling Through Taxing America's Sin: A Panel Data Study

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Abstract

This article aims to examine how sin taxation changes long-term consumer behavior regarding commodities which are deemed harmful for both health and the environment. These include tobacco, alcoholic beverages, sugar and confectionary, household energy, and motor fuel. Specifically, we examine the signaling effect from taxation which is seen if a tax increase leads to a significantly larger change in consumption than a producer price change. The empirical analysis is conducted by a US panel data study, during the period 1988-2012 for the four US census regions, using the Almost Ideal Demand System (AIDS). We find the main result to be that the signaling effect from taxation is significant for tobacco as well as for electricity and motor fuel.

Keywords: taxation; signaling; public policy; regulation; legislation; almost ideal demand system; panel data

JEL Classification System-Numbers: C23, D12, H23, I18

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1. Introduction

The aim of this article is to conduct a panel data study to consider, how sin taxation changes the long-term consumer behavior regarding commodities which are deemed harmful for both health and the environment. Specifically, the main contribution of this article is the use of US panel data during the period 1988-2012 for the following census regions: 1) Northwest; 2) Midwest; 3) South; and 4) West. We do not consider state-by-state effects due to the unavailability of data. Commodities analyzed in this paper are tobacco, alcoholic beverages, sugar and confectionary, household electricity, household natural gas, and motor fuel. Here, the focus is on the signaling effect, which, as described in more detail later, is seen as an additional informational effect from taxation where a change in taxation leads to a greater change in demand above a basic price effect.

Taxation of commodities which produce negative externalities are deemed 'sin taxation'[2] which is defined as a sumptuary tax specifically enforced on a good which is addictive, self-destructive, and socially undesirable while raising revenue for pro-social activities[3] (Johnson and Meier, 1990; Lorenzi, 2004). As stated by Hines (2007), traditionally, sin taxation has been a common phrase for taxation on tobacco, alcohol, and unhealthy foods. However, sin taxation has also been a term used for taxation on motor fuel and appliances emitting excessive pollutants. Our objective is achieved through investigating if effects on consumer behavior differ from whether the change in consumer prices differs depending on if the price change is due to a tax change or a change in producer price. If taxation leads to a larger change in consumption than the producer price, this is referred to the 'signaling effect' of taxation (Brockwell, 2013). Here, taxation signals to the consumer the properties of the good consumed on how consumption affects negatively the public good via, e.g. pollution, or the private good via, e.g. health effects.

A key contribution of this article is to shed light on interaction effects of legislative introductions (e.g. bans and restrictions) and changes in gender shares within the U.S. Expenditure Survey. The latter being the percentage of men and women surveyed. As an increasingly popular method in empirical studies, the advantage of using panel data methods is that it accounts for unobserved heterogeneity characterizing economic agents which is not easily done with pure cross-sectional data (Semykina & Wooldridge, 2008). There exist no studies to the author's knowledge on the signaling effect using a panel data method. Specifically, this article uses panel data for the United States over the period 1988-2012.

Sin taxation as an economic instrument is an important tool to increase the cost of consumption for a commodity producing negative externalities. Sin taxation hence changes consumption behavior among households and society in the expected direction through internalizing the external costs of consumption and placing a monetary value on the impact of that consumption (Crawford & Sobel, 1982). Our paper focuses on the most discussed examples of sin taxation: tobacco, alcohol, sugar and confectionary, household energy, and motor fuel. This article analyzes the potential effects from taxation via the price elasticity for the particular commodity. In behavioral economics, prospect theory and the concept of loss aversion is the usual explanation of reactions to taxation (Kahneman and Tversky, 1979). Another strand of the literature diverging from basic consumer theory comes from what has been denoted 'signaling theory', which has its roots in contract theory and asymmetric information (Spence 1973, 2002).

[2] The term 'sin' is presented as a value term used by certain literature. The consumer, through consuming tobacco, alcohol, and sugar is said to lead an unhealthy lifestyle whilst putting an excess burden on the healthcare system. For environmental sin taxation, a consumer through convenience or laziness may choose to use motor fuel instead of walking, biking, or taking public transport.

[3] I.e. exercise programs, addiction treatment programs, and community leisure events.

A key addition this article makes is that legislation must be considered as an interacting effect on taxation where taxation cannot effectively transmit signals in isolation. This is due to consumers being 'less informed' about the properties and impact of a good. This lack of information on the part of the consumer seems to show a market failure and thus validates need for the government to intervene. Here, the government or regulator is considered 'better informed' through possession of statistics agencies along with specialized research groups. As this missing information holds a public good nature, the government has a key function to disseminate this through mutual communication streams (through e.g. legislation, public information campaigns, etc.) to persuade the consumer to alter beliefs (Licari & Meier, 2000). Consumers do not simply forget about the negative effects from consumption; rather there exists decay over time of the information, and the impact regarding consumption, for the given commodity.

These alterations in beliefs through changes in taxation then directly affect the consumers' utility functions. This being as two features enters the household utility function, namely, consumption and the private/public externalities. The public externality here can be, for example, environmental quality whilst the private externality can be personal health. Hence, as stated by Bovenberg and de Mooij (1994), in maximizing utility, the households adapt both features potentially as instruments for demand of private goods. The consumer may then change their preferences as beliefs change regarding the importance of the public and private good within the household's utility function.

Another basic idea is that the signaling effect from taxation may be reinforced or crowded out if a change in taxation is combined with changes in legislation. Using the methodology from Brockwell (2013) we examine the role of legislation (i.e. restrictions, advertising, etc.) and how the effects from this may interact with taxation according to how households perceive changes in the tax level.

We also find that gender is a relevant point of interest as through the U.S. Consumer Expenditure Survey [4], the sampling of men and women has changed over time quite dramatically. This is done as averages for the demographic group of consumer units (households) based on the region of residence to give a gender share. For example, on average across the four regions considered, in 1988 within the sample there were 68.75% men and 31.25% women within the survey. In 2012 this changed to 46.75% men and 53.25% women. This shows the sample has potentially been biased towards men.

This shift in gender shares over time shows there may be a selection problem in the Consumer Expenditure Survey where the sample may not be representative of the population. While this article does not look to explain the reasons for these changes, such changes can possibly be due to demographic changes, changes in the sampling method and sampling errors. Such variations in gender representation may potentially have positive or negative interactions on the signaling effect where regression results may be biased if men and women react differently to taxation. For example considering alcohol, over many years and in different countries, men are reported to drink more alcohol and experience more alcohol health-related problems than women (Plant, 1990). For these reasons, this article will add a gender-by-year interaction term between gender and taxation in order to gauge if there is any positive or negative effect on sin taxation not captured by the time trend.

A key feature of this article is the use of a panel data method which allows us to model the complexity of human behavior than what is typically achieved with aggregated time series data.

[4] The Consumer Expenditure Survey is detailed in Chapter 3.2 for the description of data.

As stated by Hsiao (2006), with panel data we may rely on the inter-individual differences (across time, groups, and regions) to reduce the collinearity between variables (through more degrees of freedom) and estimate unrestricted time-adjustment patterns. Looking at specific regional data, which have their own unique consumption and price levels, we can estimate a more accurate model detailing behavior to the relationship between producer price and the signaling effect of taxation.

This article's main objective is to analyze the overall significance of the signaling effect, along with corresponding interaction effects from legislation and gender on taxation, across the regional panel groups. The importance of this study is to gauge whether there is an effect from taxation beyond a basic price effect from information. Specific welfare calculations are beyond the scope of this study but would be an issue for future analysis. Specifically, this article aims to answer the following questions:

1) Is there a signaling effect of taxation for a given commodity?
2) Are the legislative and gender interaction effects on taxation significant in any direction?

The rest of the paper is structured as follows. In the next section we provide a more detailed background to the problem. Section 3 will outline the model used for the empirical analysis and provide a description of the data that is used. Section 4 presents the results from the analysis. Section 5, finally, gives some concluding remarks and suggestions for future research.

2. Background

As reported by the Center for Disease Control and Prevention (CDC), tobacco is the leading cause of preventable death, with annually 443,000 deaths per year[5] (one in five deaths) costing more than $193 billion each year through $97 billion in lost productivity, and $96 billion in health care expenditures (CDC, 2008a). It is then easy to see why the US Surgeon General describes smoking as, *"the most important public health issue of our time"* (USHHS, 1982). Tobacco taxation is greatly considered the most efficient policy lever to reduce tobacco consumption (USHHS, 2012). Earlier studies on price elasticities, since 1970, have varied greatly from -0.4 to -1.3 on one hand, and -0.25 and -0.50 on the other hand from another range of previous studies (Wasserman *et al.*, 1991; Chaloupka *et al.*, 2002). These results show an unclear result on the effect of price. Extensive debates exist over regional variations in taxation as well as the performance of a tax compared to legislative or educational measures to reduce tobacco consumption. Previous econometric studies have also determined that the younger generations seem to be more responsive to tobacco taxation which has meant a greater effect over time (Grossman & Chaloupka, 1997; DeCicca *et al.*, 2008).

In the United States, excessive alcohol consumption accounts for approximately 79,000 deaths per year making alcohol abuse the 3rd leading lifestyle-related cause of death nationally (Mokdad *et al.*, 2000; CDC, 2008b). In 2005, through other alcohol-related effects: health defects, violence, injuries, and risky sexual behavior, these effects have led to more than 1.6 million hospitalizations and 4 million emergency room visits. With about 38 million Americans (one in six) admitting to binge drinking[6], this issue is reported as a bigger problem than previously thought, presenting a long-term health risk problem (CDC, 2012). The CDC reports

[5] Every year, tobacco kills more Americans than HIV, drug and alcohol abuse, suicides, murders and car accidents combined (CDC, 2014).

[6] Binge drinking is defined when a person consumes 5 or more drinks for men and 4 or more drinks for women in the space of about 2 hours (NIAAA, 2004)

the key method in tackling this is through increasing alcohol taxation as well as stronger legislation of sales and marketing for alcoholic beverages. However, there appears to be no clear policy recommendation as to which method is suggested as the most efficient policy lever in tackling alcohol consumption. A review by Wagemaar *et al.* (2009) using 1,003 estimates, from 112 different studies finds that a mean of the price elasticity ranging between -0.46 (beer) and -0.80 (spirits). However, it seems to be a large variation between individuals, not the least depending on the level of consumption.

Obesity from over-consumption of sugar and confectionary goods is seen as a major issue for public health and personal attractiveness where society desires to adhere to weight norms set by public perception[7] and the public health community. With 35.7% of US adults classified as obese, this is a substantial risk factor for many serious diseases including heart disease, diabetes, and shortened life-spans. Furthermore, medical costs associated with obesity are estimated at around $147 billion; $1,429 higher than for those with normal weight (Ogden *et al.*, 2012). With the second highest proportion of obesity worldwide that is projected to dramatically increase (OECD, 2011), there is a sense of urgency for the US government to change consumer behavior and eating habits. As stated by Wang & Beydoun (2007), studies considering strategies to tackle obesity, looking at the dynamic effects of policy measures, are greatly needed. However, health issues through unhealthy food contain a different consumption dimension compared to tobacco, through the lack of an addictive chemical like nicotine (Schroeder, 2007). From a review of 160 studies on price elasticity of demand for major food categories, the mean long-run elasticity for sugar and confectionary is -0.34 (Andreyeva *et al.*, 2010). As no literature exists, to the author's knowledge, on the signaling effect within taxation, the need for a panel data study on this area is apparent.

Environmental taxation for motor fuel and household energy remains a very important issue for consumers in the face of rising motor and household energy prices. Despite these concerns, US green taxes are 3.5% of total tax revenues compared to the average of 7% for OECD countries (Milne, 2007). With rising prices and the influence of fossil fuel suppliers being a major campaign issue for politicians, justification for increasing taxes is a must to convince voters why taxes are being raised to not risk political fallout. Since the Clean Air Act of 1970, environmental regulation has started to take shape where the Environmental Protection Agency (EPA) was given responsibility in implementing these laws[8]. Despite this, in 2006 the U.S. was listed as the second highest polluter in the world with 17.3 tons of per capita CO_2 emissions (PNEAA, 2012). As reported by the EPA (2012), from 1990 to 2010, greenhouse gas emissions have increased in the U.S. by 10.5% with the biggest offenders being transportation (31%) and residential electricity consumption (22%). Whilst cars and appliances have gotten cleaner over the years, consumption of motor fuel and residential energy has still increased, which has offset this progress. To a large extent this is due to the number of vehicle miles travelled from 1990 to 2010, which has increased by 34% whilst energy demand from household energy has increased by 29%.

Compared to Europe, the demand for motor fuels is very inelastic at least in the short run partly due to the limited amount of readily available alternatives to power motor vehicles (Schimek, 1996). Through a dataset of 312 elasticity observations for gasoline demand, Brons *et al.* (2008) finds that the price elasticity of demand is quite inelastic for short-run and long-run elasticities of -0.36 and -0.81, respectively. The study also concludes that pricing policy based only on

[7] This includes perception of attractiveness from many as well as a signal of self-control and self-discipline. O'Donoghue & Rabin (2006) formalizes this as, "a time-inconsistent preference for immediate gratification".

[8] Pollution control laws delegate authority to the individual states to create their own programs in implementing the law while the EPA enforces these programs.

gasoline taxes may not be a very effective instrument to decrease the demand for gasoline. Here the results points to a high dependence of consumers on automobile transport and indicates that pricing policy could be more effective if combined with other vehicle charges and legislative introductions. Through a review of economic literature, Espey & Espey (2004) states that mean short and long run price elasticities for US residential electricity are -0.35 and -0.85, respectively. Considering residential natural gas, economic studies have had quite erratic results where Dahl (1993) states that from a review across many studies that price elasticity is around -0.27. Here we can see that price elasticities for natural gas are often more inelastic than electricity. However, the overall elasticities show that household energy demand remains inelastic to price changes. This article aims to investigate whether these previous findings are accurate through the impact of the signaling effect where no studies have done this to the author's knowledge.

3. The model and data

This section details the model and data that will be used in the empirical analysis. To model consumer behavior, this paper adapts a three-stage budgeting model where the first stage assumes the cost-minimizing household determines how much to spend on leisure, savings and consumer goods. Second, given a total budget for consumer goods, the household allocates its total expenditure for commodity groups, i.e. foodstuff, household energy, etc. Third, the household allocates expenditure on specific commodities within each group, given its budget for the commodity group. This article will conduct a panel data study over the given time period for each commodity and region during the third stage of this budgeting process.

3.1 Modeling approach

The model employed in this article expands a panel data approach upon the basic form of the AIDS (Almost Ideal Demand System) model first developed by Deaton & Muellbauer (1980), and expanded by Ghalwash (2007) and Brockwell (2013) in order to study the 'signaling effect' from taxation. This being how taxation signals additional properties of a commodity which causes an effect above a basic price effect compared to producer price. The AIDS model is used due to its desirable properties. It gives an arbitrary first-order approximation to any demand system, which means that it satisfies axioms of choice, aggregates over consumers without invoking parallel Engel curves, and is consistent with the budget constraint (through adding up) (Deaton and Muellbauer, 1980; Aasness and Rødseth, 1983). In addition, it allows for weak seperability, hence allowing for multistage budgeting[9].

This paper adapts the basic AIDS model used in Ghalwash (2007) and Brockwell (2013), which allows us to separate the effects from taxation as opposed to producer price changes (price exclusive of consumer taxes). Furthermore, we assume weak seperability. In this case this means that consumers in the first stage are assumed to determine how much to spend on various groups of commodities, given their total budget for consumption. While they are in the second stage, the consumers determine how much to spend on each separate commodity with each group. In order to determine the final total own-price and total expenditure elasticities, it is thus required to have estimates on the elasticities in each stage, i.e. both group and commodity

[9] We have also considered using an expansion of the AIDS model known as the DAIDS (Dynamic Almost Ideal Demand System). This is where the consumer's current perception of current period 'fixed cost' depends on current prices and his 'standard of living' in the last period as measured by lagged expenditure. Essentially the model measures the habit effects on the price index. However as our commodities have varying degrees of habit forming and that for most developed countries, income effects can be limited; thus incorporating the habit effect in our model may not be entirely satisfactory (Blanciforti *et al.*, 1986; Liao & Chen, 2006).

elasticities. However in the results section, the focus is on the individual commodities and their total elasticities. The results from the commodity group estimation are presented in Appendix B.

Given the multi-stage budgeting assumption, we can express the basic AIDS model for the first stage, the commodity groups as (for a particular household, state, or country)[10]:

$$w_{(r)t} = \alpha_{(r)} + \sum_{r=1}^{n} \gamma_{(r)s} \ln p_{(s)t} + \beta_{(r)} \ln(x_t/P_t) + \varepsilon_{(r)t}; \quad r = 1, \dots, n \tag{1}$$

where $r = 1, \dots, n$ denote commodity groups. Here, $w_{(r)t}$ denotes the budget share for group r at time t; p denotes the consumer price; x_t denotes the total expenditure of non-durable commodities; and P denotes the total consumer price index. Following, among others, Deaton & Muellbauer (1980b), Moschini (1995), and Ghalwash (2007), the consumer price index used is Stone's (geometric) price index given below:

$$\ln(P_t) = \sum_j w_{(r)t} \ln(p_{(r)t}) \tag{2}$$

Similarly for the second stage, the basic equation system for the individual commodities, describing allocation of expenditure within each commodity group, is expressed as:

$$w_{i(r)t} = \alpha_i + \sum_{j=1}^{m(r)} \gamma_{ij} \ln p_{jt} + \beta_i \ln(x_{(r)t}/P_{(r)t}) + \varepsilon_{it}; \quad i = 1, \dots, m(r); r = 1, \dots, n \tag{3}$$

where $i = 1, \dots, m(r)$ denote commodities within group r. Here, w_{it} denotes the budget share for commodity i within commodity group r; p_{jt} denotes the consumer price for the commodity; $x_{(r)t}$ is the total expenditure allocated to commodity group r; and $P_{(r)t}$ is the price index for the rth commodity group. As above, we use Stone's (geometric) price index:

$$\ln(P_{(r)t}) = \sum_j w_{j(r)t} \ln(p_{jt}) \tag{4}$$

Equations (1) to (3), along with the corresponding price indices, form the basic model for our purposes. To be able to test for the signaling effect, commodity prices have to be partitioned into a producer price component and a tax component. If we define the producer prices as $\overline{p}_j$ and the unit tax rate as tax_j, then the consumer price is:

$$p_j = \overline{p}_j + tax_j \tag{5a}$$

Dividing both sides with $\overline{p}_j$ we can, following some manipulation, express the consumer price as:

$$p_j = \overline{p}_j(1 + \tau_j) \tag{5b}$$

where $\tau_j = tax_j/\overline{p}_j$, i.e., the implicit tax rate for commodity j. Similarly for the commodity groups we get:

$$p_{(r)} = \overline{p}_{(r)}(1 + \tau_{(r)}) \tag{5c}$$

This allows us to rewrite equations (1) and (2) as:

[10] In this particular application, we use a panel data set covering four different US regions. In the presentation of the model below we have suppressed the index denoting region to save on notational clutter.

$$w_{(r)t} = \alpha_{(r)} + \sum_{s=1}^{n} \gamma_{(r)s} \ln\left(\overline{p}_{(s)t}\left(1+\tau_{(s)t}\right)\right) + \beta_{(r)} \ln(x_t/P_t) + \varepsilon_{(r)t}; \quad r = 1, \dots, n \tag{6}$$

$$w_{i(r)t} = \alpha_i + \sum_{j=1}^{m(r)} \gamma_{ij} \ln\left(\overline{p}_{jt}\left(1+\tau_{jt}\right)\right) + \beta_i \ln\left(x_{(r)t}/P_{(r)t}\right) + \varepsilon_{it}; \quad i = 1, \dots, n; r = 1, \dots, n \tag{7}$$

Finally, allowing for different effects from changes in producer price and taxes respectively, equations (6) and (7) can be written as:

$$w_{(r)t} = \alpha_{(r)} + \sum_{s=1}^{n} \gamma_{(r)s} \ln\left(\overline{p}_{(s)t}\right) + \sum_{j=1}^{n} \tilde{\gamma}_{(r)s} \ln\left(1+\tau_{(s)t}\right) + \beta_{(r)} \ln(x_t/P_t) + \varepsilon_{(r)t}; \quad i = 1, \dots, n \tag{8}$$

$$w_{i(r)t} = \alpha_i + \sum_{j=1}^{m(r)} \gamma_{ij} \ln\left(\overline{p}_{jt}\right) + \sum_{j=1}^{m(r)} \tilde{\gamma}_{ij} \ln\left(1+\tau_{jt}\right) + \beta_i \ln\left(x_{(r)t}/P_{(r)t}\right) + \varepsilon_{it}; \quad i = 1, \dots, n; r = 1, \dots, n \tag{9}$$

The basic specification in (8) and (9) forms the basis for our empirical model, which will take into account the specific data we have.

One addition to the model is that we include fixed effects, since we have a panel consisting of four US regions. Another addition is that we try to control for sample bias in the data, with respect to gender. The reason for this is that there is a trend within the share for females (and hence also males) in the data, in the sense that the share for females in the underlying census data increases over time (as explained in the introduction). To account for this, the model is appended with an interaction between gender shares and the tax effect, implemented for both equation (10) and (11). To allow for these interactions, this is done through samples representing the male gender share per year denoted by G with coefficient η.

In order to fully incorporate the effects of gender to the tax effect, this is included as σ_l gender level interactions. Here, all gender shares are unique amongst the panel sets. As these interactions are implicitly summed across r, j and t, we are able to write this below in the current form. Coefficients for taxation and the gender interaction effect are then added together where both may potentially influence the consumer's consumption decision. We then rewrite (8) and (9) as:

$$w_{(r)t} = \alpha_{(r)} + \tilde{\alpha} + \sum_{s=1}^{n} \gamma_{(r)s} \ln\left(\overline{p}_{(s)t}\right) + \left(\sum_{s=1}^{n} \tilde{\gamma}_{(r)s} + \sum_{s=1}^{n} \sigma_{(r)s} G_{mt}\right) \ln\left(1+\tau_{(s)t}\right) + \beta_{(r)} \ln(x_t/P_t) + \sum_{m} \eta_{(r)s} G_{mt} + \varepsilon_{(r)t} \tag{10}$$

$$w_{i(r)t} = \alpha_i + \tilde{\alpha} + \sum_{j=1}^{m(r)} \gamma_{ij} \ln\left(\overline{p}_{jt}\right) + \left(\sum_{j=1}^{m(r)} \tilde{\gamma}_{ij} + \sum_{j=1}^{m(r)} \sigma_j G_{mt}\right) \ln\left(1+\tau_{jt}\right) + \beta_i \ln\left(x_{(r)t}/P_{(r)t}\right) + \sum_{m} \eta_j G_{mt} + \varepsilon_{it}; \quad i = 1, \dots, n; r = 1, \dots, n \tag{11}$$

where $\tilde{\alpha}_k$ denotes the region panel fixed effect where this is separated from the constant term to fit in with our fixed effects model. Considering the second stage, equation (11), the demand for commodities within groups, possible effects from legislation and information is allowed for in the same principle as for gender. This is done through a set of dummy variables, representing

major legislative reforms or information campaigns upon the point of implementation for specific commodities. The basic idea is that legislation and information may reinforce the tax effect. Legislative effects are denoted as an array of q dummy variables noted by L with coefficient μ which takes the value of 0 at 1988 and then 1 for each major advertising/legislative change[11]. From this it is shown that information from each legislative increase is collected by the consumer and then added and reflected within their consumption behavior as an index of regulatory pressure. To fully incorporate the effects of the legislative increases, it is appropriate to include interaction effects to the tax element. This is seen in equation (12) given by ψ_q for q legislative introductions. As with gender, coefficients for taxation and the interaction effect are added together where both influence the consumers' consumption decision. However, as legislation in not unique to a panel data group, but rather on the federal level, we do not denote legislation over k. Implicitly, legislation interactions are summed across j and t.

$$w_{i(r)t} = \alpha_i + \tilde{\alpha}_k + \sum_{j=1}^{m(r)} \gamma_{ijk} \ln\left(\overline{p}_{jt}\right) + \left(\sum_{j=1}^{m(r)} \tilde{\gamma}_{ij} + \sum_{j=1}^{m(r)} \sigma_j G_{mt} + \sum_{q=1}^{Q} \psi_q L_q\right) \ln(1+\tau_{jt}) + \beta_i \ln\left(x_{(r)t}/P_{(r)t}\right) + \sum_{m} \eta_j G_{mt} + \sum_{q} \mu_q L_q + \varepsilon_{ikt}; \quad i = 1, \dots, n; r = 1, \dots, n \tag{12}$$

where $i = 1, \dots, mq$ denote commodities within the commodity group. Parameters estimated from (10) and (12) for the commodity group and individual commodity, respectively, are then collected. These are then used to evaluate consumers' sensitivity to a tax change compared to a pure price change, i.e. the long-run price and tax elasticities, as well as the income, i.e. expenditure elasticities. Calculations of the own-price and expenditure elasticities are done at both stages, i.e. between and within groups. For simplicity of readability, t is omitted. For simplicity, suppressing group indices, the between group elasticities for the individual commodity are calculated as:

$$E_{i(r)} = \frac{\beta_{i(r)}}{w_{i(r)}} + 1; \quad i = 1, \dots, n; \; r = 1, \dots, n \tag{13}$$

$$e_{i(r)} = \left(\frac{\gamma_{i(r)} - \beta_{i(r)} w_{(r)}}{w_{i(r)k}} - \delta_{i(r)}\right); \quad i = 1, \dots, n; r = 1, \dots, n \tag{14}$$

$$\tilde{e}_{i(r)} = \left(\frac{\tilde{\gamma}_{i(r)} - \beta_{i(r)} w_{(r)}}{w_{i(r)}} - \delta_{i(r)}\right); \quad i = 1, \dots, n; r = 1, \dots, n \tag{15}$$

where $E_{i(r)}$ denotes the expenditure elasticity for commodity i in group r, $e_{i(r)}$ is the uncompensated producer price elasticity, and $\tilde{e}_{i(r)}$ is the uncompensated tax elasticity. Furthermore, $\delta_{i(r)}$ is equal to one when $r = s$ and zero otherwise.

To incorporate the interaction terms for gender and legislation, these are added to the coefficient for taxation, as seen in (12), in order to rewrite the equation as given in (16):

$$\tilde{e}_{i(r)} = \left(\frac{\left(\tilde{\gamma}_{i(r)} + \sigma_j G_{mt} + \psi_q L_q\right) - \beta_{i(r)} w_{(r)}}{w_{i(r)}} - \delta_{i(r)}\right); \quad i = 1, \dots, n; r = 1, \dots, n \tag{16}$$

The existence of the signaling effect is seen from this model through a difference between the elasticities for the producer price and the tax element. This provides ease of analysis than simply tests if either are equal than zero. Through bootstrapping the difference between the tax

[11] Details on the determination of these values are seen in section 2.2 and illustrated in Appendix A

elasticity and the producer price elasticity, we obtain a distribution of the difference in order to test the following null hypothesis and one-sided hypothesis (excluding notation for simplicity):

$$H_0\colon\ \tilde{e} = e$$

$$H_A\colon\ \tilde{e} > e$$

If we may reject the null hypothesis of parameter equality whilst not being able to reject the alternative one-sided hypothesis, this would indicate to us a statistically significant signaling effect. No significant difference between these elasticities may indicate that the increase in tax and an increase in producer price would have the same magnitude of effect.

Allowing the expenditure elasticity within the *r*th group to be $E_{(r)}$, we may denote the total expenditure elasticity for the *i*th good within the *r*th group of goods, $E_{i(r)}$ to be:

$$E_{i(r)} = E_{(r)}E_{i(r)} \tag{17}$$

Through the similar principle, we can express the within own-price elasticity of the *i*th good within the *r*th group of goods as E_i. Thus the total price elasticity for the *i*th good within the *r*th group of goods, e_{ij}, can be expressed as:

$$e_{ij(r)} = \delta_{i(r)}e_{ij(r)} + E_{i(r)}w_{j(r)}\left(\delta_{i(r)} + e_{i(r)}\right) \tag{18}$$

This total price elasticity consists of two components. The first part, being the direct effect, represents the subgroup elasticity. The second part is the indirect effect which is a product of three factors. The first of these factors measures the relative change in the group price index when the price of the *i*th good changes (equal to the budget share). The second factor measures the effect a change in the price index has on the group expenditure $\left(1 + e_{i(r)}\right)$. Finally the third factor measures the effect of the change in within group expenditure has on the consumption of the *i*th good $\left(E_{i(r)}\right)$.

Alternatively, another estimation procedure that can be considered is use of the Quadratic Almost Ideal Demand System (QUAIDS) which is a parametric demand model by Banks et al. (1992) combining the empirical flexibility of quadratic (non-linear) logarithmic Engel curves with integrability of cross product measurement through Generalized Method of Moments (GMM) procedure estimation. The basic assumption of the demand model is that there is a non-linear relationship between income and expenditure. The presence of an added quadratic element helps to capture the effects of non-linear Engel curves, to which the basic AIDS model has difficulty doing. The advantage of such an approach is that there is no requirement of any *a priori* specification of the form of the demand function which avoids misspecification of the parametric model. For an expanded view of the model, see Jones and Mazzi (1996) who considers effects of tobacco consumption and taxation in Italy and Abdulai (2002) who considers household demand for food in Switzerland. A regression is done using the QUAIDS approach as a robustness check of the results.

3.2 Description of the Data

This article uses publicly available datasets covering the years 1988-2012 from the U.S. Bureau of Labor Statistics (BLS). To conduct a panel data analysis by region of residence, specific consumption and price data is used covering four regions: 1) Northeast, 2) Midwest, 3) South, and 4) West. Datasets used are the Consumer Price Index, Producer Price Index, as well as the Consumer Expenditure Survey. The Consumer Expenditure Survey consists of two national surveys: the Quarterly Interview Survey and the Diary Survey. These surveys cover an extensive list of products and services including data on their expenditures, income, and consumer unit

characteristics. Households are selected as part of a scientifically determined sample representing thousands of households. Panel data is not conducted by a state-by-state basis due to unavailability of the Consumer Expenditure Survey data. Furthermore, data on gender, in order to calculate the interaction effect from gender, is also given from the Consumer Expenditure Survey based on the region of residence. These values are given as the percentage share of men interviewed through the survey. The timeline goes back as far as 1988 due to the Consumer Expenditure Survey being incomplete before this year. Individual states are not considered as there is incomplete information regarding price levels and consumption. Furthermore, data from the Consumer Expenditure Survey is provided yearly for the census regions considered; the Consumer and Producer Price Indices are given monthly where we take the average across the year to give yearly values.

As we focus on harmful commodities that a sin tax is imposed on, this article centers on a narrow list of commodity groups and commodities. The commodities within "Foodstuff" are "Tobacco", "Alcoholic Beverages", and "Sugar and Confectionary". Within "Fuels and Related Products and Power" are "Electricity", "Natural gas", and "Motor Fuel". These commodity groups and individual commodities are illustrated below with corresponding budget shares against total consumption and within the commodity group in Table 1. Here we see the average budget share nationally. As we do not consider all commodities within each commodity group, and to maintain summation across our analysis, other products within "Foodstuff" and "Fuels and Related Products and Power" are included in the category "Other". For example in Foodstuff, "Other Foodstuff" includes meat, dairy products amongst others. In Fuels and Related Products and Power, "Other Fuels" includes coal, light fuels, and firewood.

Table 1: Commodity Groups and Individual Commodities:

Commodity Group	**Budget Share**	**Individual Commodity**	**Budget Share**	**Within-Group**
Foodstuff	0.1528	Tobacco	0.0078	0.0512
		Alcoholic Beverages	0.0093	0.0644
		Sugar and other Confectionary	0.0030	0.0198
		Other Foodstuff	0.1327	0.8646
Fuels and Related Products and Power	0.0758	Electricity	0.0264	0.3512
		Natural Gas	0.0089	0.1189
		Motor Fuel	0.0375	0.4903
		Other Fuels	0.0030	0.0396

As our model analyzes commodities through cross-prices with other substitutes in their commodity group, this article includes data on other commodities (not considered main commodities) where the results can be found in the appendices. Such commodities would be "Meat and Fish", "Dairy Products", "Fruits and Vegetables", and "Non-Alcoholic Beverages" within the Foodstuff commodity group. Within the Fuels and Related Products and Power commodity group, this article also analyzes "Fuel Oils and Other Fuels" which includes propane, coal and other sources of household energy. This is only given as an aggregated single unit within the BLS databases.

Legislation data is collected through the THOMAS database from the Library of Congress, through searching the bill summary and status[12], the National Archives database of Executive Orders signed by the President[13], and the U.S. Food and Drug Administration (FDA) "Guidance, Compliance, & Regulatory Information"[14]. As stated, this article only considers federal legislation (not state-specific as to fit with our national analysis) that affects the household's consumption decision directly covering the population as a whole, not a select group (e.g. children, veterans, etc.). Analyzing state-specific legislation would not be relevant for a general census region. This being as, for example, a state law passed on tobacco in Massachusetts would not have an effect in New York or any other state in the East census region. Furthermore, legislation considered is that which has been signed by the President during the stage in the legislative process, which is then communicated via the media to the general public. The list of relevant legislation can be found in Appendix A for the main commodities considered.

4. Results

Analyzing the results from the model given by equation (10), we estimate the demand model for commodity groups and individual commodities through a fixed effects model for strongly balanced[15] panel data estimated by OLS regression using the least square dummy variable (LSDV) estimator. The fixed effects (FE) specification allows the individual and time-specific effects to be correlated with the explanatory variables. It also does not require an investigator to model their correlation patterns and eliminates the time invariant unobserved effect. Furthermore, robust standard errors are used in case of potential outliers and to help correct for possible issues of heterogeneity which if unchecked would hamper estimation of the Engel curves.

The estimation results are presented in Appendix B. Here we see that the degree of explanation is quite satisfactory where no values are omitted due to collinearity. Furthermore, many of the estimated coefficients are statistically different from zero. Interaction terms for legislation and gender are separated in its own table (Tables 2b, 2d and 3b) for ease of reading. Whilst we do not analyze the results from commodity group regression, as we are interested in the individual commodity, we do present the results in the appendices as the elasticity results, later in this section (Table 2a). This is in order to determine the level of the total own-price and total expenditure elasticities for individual commodities (Table 2b).

Looking at legislation, consider tobacco for example. In Table 2b in Appendix B, looking down the column for Tobacco we see first piece of legislation implemented given by "Legislation 1" (in 1994 from Appendix A), the first interaction term is given by ("Int. Term 1"). This interaction term may then imply a significant positive or negative influence which potentially alters the effect from a change in the level of taxation to change consumer behavior. A significant positive value would suggest that the legislation introduction decreases the tax effect to signal information. A significant negative value, however, would imply that legislation reinforces the tax effect.

Considering gender interaction effects, this is given from a set of year-by-year shares which then present an interaction effect on the taxation term as with legislation. To this effect a significantly

[12] THOMAS database – Search Bill Summary & Status: http://thomas.loc.gov/home/LegislativeData.php?n=BSS
[13] National Archives Executive Orders: http://www.archives.gov/federal-register/executive-orders/
[14] FDA Guidance, Compliance & Regulatory Information:
http://www.fda.gov/drugs/guidancecomplianceregulatoryinformation/default.htm
[15] "Strongly balanced" means that there are no missing or equal amounts of data between the panel data sets.

positive gender interaction effect would mean that gender would have a positive correlation towards the tax effect while a negative value would imply the opposite. For the purposes of this article our main focus for the results is on the main commodities in the "Foodstuff" commodity group (tobacco, alcoholic beverages, and sugar and confectionary) and the "Fuels and Related Products and Power" commodity group (electricity, natural gas, and motor fuel).

Looking at the results for the demand system parameter estimates (Appendix B), for legislation interaction terms, we focus on the individual commodities, where legislation is targeted at, and not the main commodity groups. For details on the legislation please see the Appendix. Considering the "Foodstuff" commodity group, for "Sugar and Confectionary", we see two statistically significant interaction terms for Int. Term 1 (1990) referring to the "Nutrition Labeling and Education Act" and Int. Term 4 (2006) referring to the FDA revision of labels concerning trans-fat and fatty acid quantities. Both significant interaction effects are of a negative value suggesting an effective legislation introduction reinforcing the tax effect to reduce consumption. For "Tobacco" and "Alcoholic Beverages" we however find no significant interaction effects from legislation which implies that legislation has not been an effective motivator to the performance of taxation.

Considering commodities in the "Fuels and Related Products and Power" commodity group, for "Natural Gas" we see one significant interaction effect of a positive value within Int. Term 2 (2005) referring to the "Energy Policy Act". This implies that the legislation is a significant influence on taxation to convey information to the consumer; however, as it is of a positive direction, this implies that this piece of legislation crowds out the tax effect. For "Electricity" and "Motor Fuel, however, we find no significant interaction effects from legislation implying that legislation has not effectively influences the performance to convey information from taxation.

Considering the interaction effects from gender shares, from the "Foodstuff" and "Fuels and Related Products and Power" commodity groups, we find no statistically significant values from the gender share and statistically significant interaction effects from the gender share. The point of considering this was to see if misrepresentation of the gender levels in the Consumer Expenditure Survey from the start of our timeline, to expected levels at the end of our timeline have had any effects; as well as acting as a control. This implies to us that the change in gender share through our timeline has not significantly influenced the performance of the tax effect from price effects or to convey information to the consumer.

Through a two-tailed Wald test of the linear hypothesis (as seen below in Table 2), following estimates of the parameters for producer price and taxation, we test if these are significantly equal or if one is significantly larger or less than the other. An advantage of using this method, as opposed to the Chow test for parameter equality, is that there is no maintained assumption that sample variances for the parameters are equal throughout the timeline. Our main hypothesis is that parameter for producer price is greater than or equal to the parameter for taxation. If we may reject this hypothesis, this implies that taxation holds more persuasive power in changing consumption than producer price in general.

From our results, for electricity we may reject the null hypothesis at the 5% level that the parameter for producer price is larger than or equal to that of taxation. However, for the other individual commodities considered, results suggest that we may not reject the null hypothesis. This provides an estimate of parameter equality which will then be progressed further when considering long-run own-price elasticities.

Table 2: F-Test for Parameter Equality:

Commodity	F-test	Null Hypothesis: $\gamma_{ij} \geq \overline{\gamma}_{ij}$
Tobacco	0.00	Do not reject (0.4757)
Alcoholic Beverages	0.00	Do not reject (0.4794)
Sugar and Confectionary	22.31	Do not reject (0.9910)
Electricity	6.22	Reject** (0.0441)
Natural Gas	0.00	Do not reject (0.5077)
Motor Fuel	0.28	Do not reject (0.3168)

***, **, *: Significant at the 1%, 5% and 10% levels respectively

Given the parameter estimates, we can now calculate the expenditure and price elasticities according to equations (11), (12) and (14). Using the mean value for the producer price, taxation, and total expenditure from 1970 to 2011 we may calculate the own-price and expenditure elasticities. To test whether the elasticities are significant we use the bootstrap method with 10,000[16] repeated random samples of the LAIDS model. Bootstrapping here is advantageous as it does not assume a specific probability distribution of the data, but relies on the empirical distribution (Wehrens *et al.*, 2000).

The overall objective of this article is to assess through a panel data perspective how consumers among various regional panels react to changes in price and taxation as well as legislation and gender interaction effects. Hence, we analyze if there is any difference on the effect on consumption resulting from the source of the price change. Through the linear almost ideal demand model system used and the resulting elasticities, this has been achieved through partitioning producer price and taxation from consumer prices. Specifically, we analyze if the pure tax effect send a separate signal on top of the price effect from a change in producer price. As the commodity group estimates figure in to our equations for the individual commodity, results for the commodity group are provided and as a reference. These results are presented below for the commodity group (Table 3a) and for the individual commodities (Table 3b) with analysis of the own-price elasticities in the conclusion.

[16] As available computing power has increased over the years, it is recommended from economic literature that 10,000 bootstrap samples are appropriate.

Table 3a: Estimated group own-price and expenditure elasticities:

	Own-price	Expenditure
Commodity Groups		
Foodstuff Prod. Price	-0.911	0.561
Foodstuff Tax	-0.938	
Fuels and Related Products and Power Prod. Price	-0.589	0.512
Fuels and Related Products and Power Tax	**-1.076****	
Household Supplies Prod. Price	-2.218	0.548
Apparel Prod. Price	-1.452	0.228

***, **, *: Significant at the 1%, 5% and 10% levels respectively

Table 3b: Estimated commodity own-price and expenditure elasticities:

	Own-price	Expenditure	Total own-price	Total Expenditure
Foodstuff				
Tobacco Prod. Price	-0.744	0.889	-0.743	0.499
Tobacco Tax	**-1.020***		**-1.019**	
Alcoholic Beverages Prod. Price	-0.661	1.789	-0.660	1.004
Alcoholic Beverages Tax	-1.582		-1.581	
Sugar and Confectionary Prod. Price	-1.146	0.652	-1.145	0.366
Sugar and Confectionary Tax	-0.273		-0.272	
Meats and Fish Prod. Price	2.228	0.904	2.229	0.507
Dairy Products Prod. Price	-0.047	0.974	-0.046	0.546
Fruits and Vegetables Prod. Price	-1.402	0.807	-1.401	0.453
Non-Alcoholic Beverages Prod. Price	-0.707	0.887	-0.707	0.498
Fuels and Related Products and Power				
Electricity Prod. Price	-0.091	0.458	-0.096	0.234
Electricity Tax	**-0.758****		**-0.759**	
Natural Gas Prod. Price	0.253	0.066	0.254	0.034
Natural Gas Tax	1.075		1.075	
Motor Fuel Prod. Price	-0.121	0.293	-0.116	0.164
Motor Fuel Tax	**-0.576****		**-0.577**	
Fuel Oils and Other Fuels Prod. Price	-1.000	0.890	-0.999	0.456

***, **, *: Significant at the 1%, 5% and 10% levels respectively

We see from the results above, negative total own-price elasticities between zero and one implies that as price goes up, consumption goes down whilst still implying a higher budget share despite lower consumption. A negative value above one in absolute values would imply that as price goes up, consumption decreases while budget shares would also decrease. Considering individual commodities in Table 3b, within the Foodstuff commodity group, consumers seem

more sensitive to a change in the tax level than a producer price change for only tobacco with total own-price elasticity significantly larger than one in absolute terms for tobacco and alcoholic beverages. This indicates a quite large reduction in consumption and also a decrease in budget share. With higher expenditure elasticities over one, we see that alcoholic beverages can be classified as a 'luxury good' with a value of 1.789 where a change in income can have a greater effect on consumption. With expenditure elasticities below one, tobacco (0.889) as well as sugar and confectionary (0.652) can be considered 'necessity goods'.

From our results, we see that there exists a significant signaling effect from tobacco taxation at the 10% level with an own-price elasticity of -1.02, larger than that for producer price at -0.744. This shows us that tobacco is neither elastic nor inelastic as a 1% change in taxation implies a -1.02% change in consumption, showing that changes in consumption and tax follow an almost 1:1 relationship. This follows from what is expected as younger generations over the past few decades have been educated and communicated to quite heavily on the effects from tobacco consumption. However, we can see no significant results for alcoholic beverages or sugar and confectionary.

For the commodity group, "Fuels and Related Products and Power", consumers seem more sensitive to a change in the tax level than a producer price change for electricity and motor fuel. However, as neither holds own-price elasticities greater than one in absolute terms, this indicates that a decrease in consumption is not also followed by a decrease in the budget share. With very low expenditure elasticities, nearer to zero; we see that electricity, natural gas, and motor fuel can be considered 'necessity goods' at 0.458, 0.066, and 0.293, respectively.

As seen above, for electricity we find a significant signaling effect from taxation at the 5% level where the own-price elasticity of electricity taxation (-0.758) greatly exceeds that seen for producer price (-0.091). This shows that consumers are more responsive to information from taxation in incentivizing sustained decreased consumption. Interestingly, the own-price elasticity for producer price is very low where an increase in producer price of 1% would decrease consumption by 0.09% which implies that consumers are very unresponsive to producer prices. Additionally, we also see a statistically significant result within motor fuel taxation at the 5% level. The results show that own-price elasticity is indeed quite inelastic, but that the own-price elasticity of motor fuel taxation (-0.577) is larger than the own-price elasticity for producer price (-0.121) which implies that taxation holds an added informational effect above the price effect. However, no significant results are seen regarding natural gas.

Conducting post-estimation tests, we run a Wooldridge test for autocorrelation in panel data. If there exists autocorrelation, where error covariances are not zero, this would imply possible model misspecification or errors of measurement in the dependent variable where the error term will pick up systematic mistakes. The null hypothesis is that there is no first-order autocorrelation where results are included in Table 1 in Appendix C. From the results we can see that we do not reject the null hypothesis for each main variable considered. This this indicates to us that we do not have problems of autocorrelation within our analysis.

As a robustness check, described in the methodology, QUAIDS estimation is done through combining the various budget shares and prices for the main commodities. The point here is to see whether we obtain similar results to back up our analysis. Coefficient results can be provided upon request. From the results obtained, we see that the parameter estimates between the AIDS and QUAIDS models is similar in significant terms which allows us to presume that we have an efficient estimation method. A drawback of the QUAIDS model is that it does not allow ease of analysis when partitioning producer price and taxation from consumer price. However, we are

able to see further effects of cross-commodity effects that cannot be gathered from the AIDS approach, which would be a good idea for future studies.

A further test that we conduct is to conduct our panel data regression without partitioning producer price and taxation from consumer price. Instead regression is done on consumer price as a single price variable to assess whether we these results are significantly different from the price effects in our main results. The point of this is to determine whether consumers notice, a statistically significant difference as to where the price effect comes from. If so, this would further validate the existence of a signaling effect. These elasticities are presented in Table 2 in Appendix C. Through a non-hypothesis testing between parameters of consumer price, producer price and taxation, we see that there is a significant difference between the two which supports our earlier assertion.

5. Conclusion

From our results we can see a significant signaling effect for tobacco at the 10% level. We also see that the results from the own-price elasticity for taxation (-1.02) is less than that given by Ross and Chalpoupka (2004) of -1.5. This shows that tobacco is more inelastic than previously estimated which is not surprising given the addictive nature of tobacco. Within the coefficient estimates (Appendix B) we find no significant interaction terms on taxation from legislation. These results do not imply that legislation is not significant in reinforcing the effects from taxation to change consumer information; rather, policymakers may look to alter existing legislation and consider effective new legislation. Thus, a suitable policy suggestion may be that policymakers should consider taxation as the most useful policy tool for signaling the harmful properties and effects from tobacco consumption.

As we see no significant signaling effect for alcoholic beverages or for sugar and confectionary, we cannot state that taxation would not be an appropriate policy tool. Simply, the signaling effect is not as large as for tobacco in significant terms. Hence the government may be advised to pursue other more direct signals to the consumer along with taxation. For alcoholic beverages, as for tobacco, we find no statistically significant interaction terms from legislation on taxation. However, for sugar and confectionary, we find two significant interaction effects from Int. Term 1 (1990) referring to the "Nutrition Labeling and Education Act" and Int. Term 4 (2006) referring to the FDA revision for labelling of trans-fat and fatty acid amounts. This shows that legislation has had a definite impact on the performance of taxation to communicate information to the consumer. Policymakers in this case may look at increasing legislation through advertisements, education and restrictions as a tool for signaling to consumers the negative effects of alcohol and sugar overconsumption.

As stated in the results, for electricity we find a significant signaling effect from taxation at the 5% level. The own-price elasticity for electricity also encouragingly is in line with previous estimates from Espey and Espey (2004) who predict an average elasticity of -0.85. Additionally, we see no significant interaction terms from legislation which implies that legislation does not seem to have a large interaction on the ability of taxation. As a result, the policymaker in this case may consider taxation increases as the main policy tool in incentivizing sustained reductions in consumption.

As part of household energy consumption, no statistically significant signaling effects are observed within taxation of natural gas. Through insignificant results we also do not even see that taxation has a larger effect in incentivizing decreased consumption reductions than producer price. However, we see a strong ability from legislation in influencing the performance of taxation with Int. Term 2 (2005) referring to the "Energy Policy Act" mandating increased

energy labelling and energy performance on appliances as well as increasing transparency of the source of energy prices to the consumer. While no statistically significant signaling effect is found, this does not mean that taxation is not an effective policy lever. However, policymakers may look at increasing legislation to further communicate energy efficiency and energy saving techniques to the consumer.

As stated in the results, we see a statistically significant signaling effect within motor fuel taxation at the 5% level. This is a surprising result given the well-publicized dependence on petroleum. Particularly, the demand for motor fuels is very inelastic at least in the short run partly due to the limited amount of readily available alternatives to power motor vehicles which has also been seen in practice where the number of miles travelled has been increasing steadily (EPA, 2012). These results are more inelastic than those predicted by Brons *et al.* (2008) who estimated long-term price elasticities of petroleum at -0.81. Overall, a significant result seems to oppose the assumption by Brons *et al.* (2008) that pricing policy based only on gasoline taxes may not be a very effective instrument to decrease the demand for petroleum. Considering legislation, as for electricity, we see no statistically significant interaction terms from legislation where legislation appears to not have a large informational interaction effect on taxation. This seems to contradict the assertion by Brons *et al.* (2008) who claims that tax effects are more effective when combines with legislative introductions. Thus as a result, policymakers should pursue taxation as the main policy tool for incentivizing sustained reductions in consumption. This, however, may prove politically difficult given the inelastic nature of petroleum demand. Despite these challenges, consumers seem more responsive given broadcasted changes in taxation.

A point of analysis for future studies would be a state-by-state study regarding the signaling effect. As this paper assesses national effects, using regional panel data, only federal legislation implemented nationally is considered. A state-by-state analysis would also be able to utilize individual state legislation where such legislation differs state to state. Another interesting point of analysis for future studies would be inclusion of more specific groups under the "Race of Reference Person" reference group. Such data is not available to the author's knowledge for specific race groups within "White, Asian, and All Others" or for Hispanics (a growing demographic in America). Likewise for Alcoholic Beverages data is not available for subsets such as spirits, wine and beer where consumers have varying elasticity values.

A potential criticism of analyzing legislation introductions as a set of interaction terms is that this may be considered an isolated information effect to the consumer. An improvement which may be considered in a future study would be to add a decay effect of legislation as the impact of legislation may decrease over time. Another point not considered would be the impact of spending and marketing from companies producing the harmful commodity. For example, tobacco companies spent in 2006, $12.49 billion on advertising and promotional expenses in the US (FTC, 2009). As this counteracts federal and state efforts to discourage smoking, this is a factor which could be considered in a future study.

A further area of study would also be importing of harmful commodities from lower taxed states and regions where this is an issue for tobacco and alcohol as well as, but to a lesser degree, motor fuel. Further studies may also look at results on a state by state basis to give more specific policy recommendations. It may also be worthwhile and interesting to conduct a survey analysis for future studies based on values as to how certain 'values groups' may react to the signaling effect. Such values groups may be those who consider themselves religious or not (i.e. Christian, Muslim, Atheist, etc.) or those of a particular political persuasion (i.e. liberal, conservative, etc.).

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Appendix A

Table 1: Significant Tobacco Legislation

Year	Details
1994	Goals 2000: Educate America Act - Smoking is made prohibited within any indoor facility designated for kindergarten, elementary or secondary education as well as library services. Smoking is also prohibited in any facility for health care, day care or early childhood development (H.R. 1804)
2008	Consumer Product Safety Modernization Act – Expands and requires detailed labeling and product information on cigarettes. (H.R. 4040)
2009	Family Smoking Prevention and Tobacco Control Act - Legislation imposing new warnings and labels on tobacco products and advertising, bans on flavored cigarettes and limitations on advertising of tobacco to minors. Tobacco products must also clearly display all ingredients within the product as well stating whether the product poses a "light", "mild" or "low" health risk. Furthermore, the Food and Drug Administration (FDA) is given authority to regulate tobacco products (H.R. 1256)

Table 2: Significant Alcohol Legislation:

Year	Details
1990	Crime Control Act - Authorizes funds to establish "drug-free school zones" within a certain geographical boundary of a place of education to eliminate consumption of alcohol within these zones (S. 3266)
1992	ADAMHA Reorganization Act – Establishes provisions mandating assistance to communities to develop comprehensive long-term alcohol abuse prevention strategies and evaluation of different community approaches to prevention (S. 1306)
2006	Sober Truth on Preventing Underage Drinking Act or the STOP Act – Amendment to the Public Health Service Act to strengthen laws for underage drinking, provide education to young adults and schools/universities on overconsumption of alcohol and education/surveys to adults exploring attitudes and use of alcoholic beverages (H.R. 864)

Table 3: Significant Fatty Foods Legislation:

Year	Details
1990	Nutrition Labeling and Education Act - Deems a food misbranded unless the label bears: (1) nutrition information providing the serving size or common household unit of measurement; (2) the number of servings per container; (3) the number of calories per serving; (4) the amount of total fat, cholesterol, sodium, carbohydrates, sugars, protein and dietary fiber per serving; (5) any other additional nutrients. Such information must be clearly labeled. (H.R. 3562)
1992	FDA Revision of the Nutrition Labeling and Education Act of 1990. Easier serving information to be included on all foods in an easy-to-read format.
2003	Trans Fatty Acids in Nutrition Labeling - The FDA imposed a rule that all trans fatty acids be declared in the nutritional label of conventional foods and dietary supplements. Warnings are to be placed stating, "Intake of trans fat should be as low as possible". Those products with 0.5 grams of trans fat or under cannot list their product as having 0 grams of trans fat (21 CFR Part 101)
2006	FDA revision of (21 CFR Part 101) stating that the trans-fat amounts must be communicated against recommended daily intake of fatty acids.

Table 4: Significant Household Energy Legislation:

Year	Details
1991	To establish a Comprehensive Energy Conservation Program - Amends the Internal Revenue Code to establish income tax credit for heating, cooling or hot water systems operated directly by renewable energy sources. (H.R. 1196)
2005	Energy Policy Act - Requiring accurate energy labelling on commercial equipment of how energy efficient the product is. Transparency on gas and electricity markets are made available to the consumer (H.R. 6)
2006	Tax Relief and Health Care Act - Credit subsidies given to consumers who invest in renewable energy for the household (H.R. 6111)
2007	Energy Independence and Security Act - Directs the Secretary for Energy to conduct a proactive national program of consumer awareness, information and education about lamp labels and energy-efficient lighting choices. Also sets up a comprehensive grant program for households which set up solar energy products.

Table 5: Significant Motor Fuel Legislation:

Year	Details
1991	Fuel-Efficient Vehicle Purchase Incentive Act - Requires all new vehicles to have displayed on the dealer sticker the carbon dioxide emissions standard for the size class of that vehicle as well as the rebate or fee which the consumer will receive or pay in connection with the purchase of that vehicle. (H.R. 1583)
1992	Alternative Fuels Incentive Act of 1991 - Amends the Internal Revenue Code to permit an income tax credit for investments in qualified clean-burning motor vehicle fuel property. (H.R. 1497)
2005	Energy Policy Act - Requires up to date accurate energy labeling on commercial vehicles of how energy efficient the product is in terms of the impact on the environment and comparison to normal fuel efficiency standards. (H.R. 6111)
2007	Energy Independence and Security Act - Instructs manufacturers to label all new automobiles with information and a rating system on an automobile's performance on the basis of criteria reflecting fuel economy and greenhouse gas and other emissions. Also directs the transportation authorities to develop a consumer education program on the benefits of alternative fuel in automobiles and resulting fuel savings. (H.R. 6)

Appendix B

Table 1: Demand System Parameter Estimates for the Main Commodity Groups:

	Foodstuff	**Fuels and Power**	**Household Supplies**	**Apparel**
Constant	0.1815 (2.06)	0.0202 (0.50)	0.2345 (3.14)	0.0303 (0.68)
Foodstuff Price	0.0034 (0.52)	-0.0050 (-2.18)	-0.0202 (-3.03)	0.0032 (0.68)
Foodstuff Tax	-0.0008 (-0.02)	0.0005 (0.22)	-0.0029 (-0.85)	-0.0075 (-2.28)
Fuels and Power Price	0.0038 (0.68)	0.0373 (14.41)	0.0078 (3.77)	0.0029 (0.53)
Fuels and Power Tax	-0.0073 (-0.58)	-0.0131 (-0.65)	0.0103 (1.37)	-0.0048 (-0.52)
Household Supplies Price	0.0641 (2.25)	0.0411 (2.76)	-0.0627 (-2.88)	0.0554 (2.96)
Household Supplies Tax	0.0409 (5.13)	0.0292 (1.63)	-0.0547 (-1.55)	0.0321 (2.85)
Apparel Price	-0.0175 (-0.48)	-0.0086 (-1.01)	0.0621 (7.32)	-0.0216 (-1.10)
Apparel Tax	-0.0161 (-1.19)	-0.0168 (-2.19)	0.0141 (1.57)	0.0573 (1.25)
Expenditure	-0.067 (-19.18)	-0.0504 (-7.46)	-0.0228 (-5.79)	-0.0343 (-2.53)
Gender	-0.0001 (-0.24)	-0.0001 (-0.78)	-0.0003 (-3.94)	-0.0001 (-0.60)
Gender Int. Term	-0.0001 (-0.18)	0.0009 (2.34)	0.0011 (2.00)	-0.0008 (-0.96)

Table 2a: Demand System Parameter Estimates for the Foodstuff Subgroup:

	Tobacco	**Alcoholic Beverages**	**Sugar and Confectionary**
Constant	0.0409 (1.71)	0.0604 (2.72)	-0.0127 (-1.56)
Tobacco Price	0.0019 (2.83)	-0.0006 (-0.59)	-0.0018 (-4.46)
Tobacco Tax	0.0014 (0.17)	0.0050 (1.87)	0.0051 (1.93)
Alcoholic Beverages Price	-0.0121 (-1.69)	0.0032 (0.15)	0.0062 (2.13)
Alcoholic Beverages Tax	0.0007 (0.17)	0.0054 (0.28)	-0.0023 (-0.82)
Sugar and Confectionary Price	-0.0063 (-2.92)	-0.0093 (-0.45)	-0.0004 (-0.13)
Sugar and Confectionary Tax	-0.0066 (-2.92)	0.0016 (0.16)	0.0638 (5.77)
Meat and Fish Price	0.0005 (0.13)	0.0031 (0.55)	-0.0063 (-3.67)
Meat and Fish Tax	0.0018 (0.32)	0.0003 (0.05)	-0.0039 (-1.64)
Dairy Products Price	0.0009 (0.18)	-0.0020 (-0.42)	0.0069 (3.53)
Dairy Products Tax	0.0064 (1.21)	-0.0043 (-0.63)	0.0068 (2.57)
Fruits and Vegetables Price	0.0017 (0.26)	-0.0009 (-0.21)	-0.0056 (-3.59)
Fruits and Vegetables Tax	0.0020 (0.30)	0.0085 (4.23)	-0.0041 (-2.78)
Non-Alcoholic Beverages Price	0.0067 (1.20)	-0.0121 (-2.19)	0.0053 (2.59)
Non-Alcoholic Beverages Tax	-0.0001 (-0.02)	-0.0161 (-0.62)	0.0142 (1.26)
Expenditure	-0.0008 (-0.61)	0.0074 (5.49)	-0.0010 (-2.17)

Table 2b: Demand System Interaction Term Parameter Estimates for the Foodstuff Subgroup:

	Tobacco	**Alcoholic Beverages**	**Sugar and Confectionary**
Legislation 1	-0.0003 (-0.68)	0.0001 (0.26)	0.0016 (4.36)
Int. Term 1	-0.0014 (-0.60)	-0.0134 (-1.98)	-0.0475 (-4.91)
Legislation 2	-0.0004 (-0.64)	0.0008 (3.66)	-0.0017 (-1.87)
Int. Term 2	-0.0015 (-0.56)	0.0028 (1.17)	0.0055 (0.61)
Legislation 3	-0.0049 (-0.91)	N/A	-0.0001 (-0.27)
Int. Term 3	0.0150 (1.32)	N/A	-0.0006 (-1.30)
Legislation 4	N/A	N/A	0.0001 (0.17)
Int. Term 4	N/A	N/A	-0.0193 (-3.30)
Gender	0.0001 (1.43)	0.00002 (0.42)	0.00002 (1.25)
Gender Int. Term	-0.0001 (-0.72)	-0.0001 (-0.39)	-0.0005 (-1.82)

Int. Term m = Interaction Term for legislation m; N/A = Not Applicable

Table 2c: Demand System Parameter Estimates for the Foodstuff Subgroup:

	Meats and Fish	**Dairy Products**	**Fruits and Vegetables**	**Non-Alcoholic Beverages**
Constant	0.1614 (2.84)	0.0104 (1.26)	-0.0159 (-1.02)	-0.0124 (-1.12)
Tobacco Price	0.0034 (1.42)	-0.0006 (-0.85)	0.0001 (0.03)	-0.0006 (-1.19)
Tobacco Tax	-0.0120 (-2.78)	-0.0012 (-1.61)	0.0016 (0.94)	-0.0008 (-0.85)
Alcoholic Beverages Price	-0.0997 (-4.73)	-0.0002 (-0.04)	0.0055 (0.62)	-0.0020 (-0.51)
Alcoholic Beverages Tax	-0.0305 (-3.63)	-0.0018 (-1.09)	-0.0015 (-0.16)	0.0006 (0.21)
Sugar and Confectionary Price	0.0670 (3.73)	0.0021 (0.43)	0.0140 (2.27)	0.0055 (1.55)
Sugar and Confectionary Tax	0.0596 (4.56)	-0.0015 (-1.19)	0.0119 (1.37)	-0.0001 (-0.03)
Meat and Fish Price	0.0629 (4.34)	-0.0040 (-1.32)	-0.0048 (-0.85)	0.0036 (2.01)
Meat and Fish Tax	-0.1092 (-2.52)	-0.0057 (-1.49)	-0.0125 (-1.25)	0.0002 (0.08)
Dairy Products Price	-0.0385 (-2.77)	0.0084 (3.75)	0.0020 (0.59)	-0.0029 (-3.06)
Dairy Products Tax	-0.0244 (-1.36)	0.0189 (1.43)	0.0053 (1.28)	-0.0019 (-1.30)
Fruits and Vegetables Price	-0.0059 (-0.59)	-0.0061 (-2.60)	-0.0055 (-1.10)	-0.0003 (-0.25)
Fruits and Vegetables Tax	-0.0175 (-1.52)	-0.0071 (-5.01)	-0.0305 (-1.56)	-0.0034 (-1.54)
Non-Alcoholic Beverages Price	-0.0067 (-0.64)	0.0006 (0.19)	-0.0002 (-0.03)	0.0020 (1.08)
Non-Alcoholic Beverages Tax	0.0338 (1.26)	-0.0027 (-0.39)	0.0129 (0.87)	0.0059 (0.35)
Expenditure	-0.0019 (-0.41)	-0.0002 (-0.11)	-0.0026 (-0.58)	

Table 2d: Demand System Interaction Term Parameter Estimates for the Foodstuff Subgroup:

	Meats and Fish	**Dairy Products**	**Fruits and Vegetables**	**Non-Alcoholic Beverages**
Gender	-0.0008 (-6.17)	0.00001 (0.57)	-0.0001 (-1.13)	-6.58e-06 (-0.50)
Gender Int. Term	0.0032 (4.20)	-0.0002 (-0.85)	0.0003 (1.05)	0.0001 (0.29)

Table 3a: Demand System Parameter Estimates for the Fuels and Power Subgroup:

	Electricity	**Natural Gas**	**Motor Fuel**	**Other Fuels**
Constant	-0.0395 (-1.60)	-0.0445 (-1.40)	0.0554 (0.68)	-0.0084 (-1.02)
Electricity Price	0.0261 (2.60)	0.0085 (1.23)	-0.0230 (-1.69)	0.0010 (1.42)
Electricity Tax	-0.0051 (-0.37)	0.0018 (3.12)	0.0067 (1.36)	0.0002 (0.18)
Natural Gas Price	-0.0006 (-0.33)	0.0103 (5.01)	0.0039 (1.23)	-0.0011 (-1.45)
Natural Gas Tax	-0.0028 (-1.05)	0.0100 (0.82)	0.0045 (1.15)	-0.0033 (-1.99)
Motor Fuel Price	0.0005 (0.09)	-0.0025 (-1.63)	0.0300 (4.73)	0.0017 (1.17)
Motor Fuel Tax	0.0036 (0.62)	-0.0024 (-0.98)	0.0573 (1.05)	-0.0002 (-0.33)
Other Fuels Price	-0.00003 (-0.01)	0.0010 (1.10)	0.0072 (0.94)	-0.0126 (-4.70)
Other Fuels Tax	-0.0001 (-0.01)	0.0001 (0.09)	0.0101 (1.06)	-0.0014 (-0.31)
Expenditure	-0.0132 (-2.02)	-0.0077 (-2.56)	-0.0248 (-3.79)	-0.0002 (-0.17)

Table 3b: Demand System Parameter Estimates for the Fuels and Power Subgroup:

	Electricity	**Natural Gas**	**Motor Fuel**	**Other Fuels**
Legislation 1	-0.0015 (-1.11)	-0.0004 (-0.58)	-0.0044 (-1.98)	N/A
Int. Term 1	0.0085 (0.94)	0.0070 (0.79)	-0.0255 (-1.65)	N/A
Legislation 2	0.0012 (1.30)	0.0077 (6.38)	-0.0014 (-0.28)	N/A
Int. Term 2	0.0028 (1.06)	0.0122 (7.87)	-0.0207 (-0.90)	N/A
Legislation 3	0.0005 (0.86)	-0.0039 (-1.14)	0.0008 (0.18)	N/A
Int. Term 3	-0.0042 (-1.18)	-0.0041 (-0.53)	0.0028 (0.15)	N/A
Legislation 4	-0.0004 (-0.57)	-0.0043 (-1.08)	N/A	N/A
Int. Term 4	0.0035 (2.08)	-0.0080 (-0.98)	N/A	N/A
Gender	0.0001 (0.92)	0.0001 (2.23)	0.0001 (0.66)	0.0001 (2.01)
Gender Int. Term	0.0001 (0.22)	-0.0001 (-1.40)	0.0002 (0.30)	0.0001 (0.66)

Int. Term m = Interaction Term for legislation m; N/A = Not Applicable

Appendix C

Table 1: Wooldridge test for autocorrelation in panel data:

Commodity	F-test	Prob.
Tobacco	1.163	0.3599
Alcoholic Beverages	0.683	0.4690
Sugar and Confectionary	0.289	0.6280
Electricity	5.836	0.1001
Natural Gas	1.801	0.2722
Motor Fuel	5.170	0.1076

Table 2: Estimated own-price and expenditure elasticities – Consumer Price:

	Own-price	Expenditure
Commodity Groups		
Foodstuff	-0.934	0.564
Fuels and Related Products and Power	-0.537	0.563
Household Supplies	-0.186	0.909
Apparel	-0.734	0.357
Foodstuff		
Tobacco Price	-0.615	1.028
Alcoholic Beverages Price	-0.893	1.925
Sugar and Confectionary Price	-1.584	0.601
Meats and Fish Price	-0.714	0.279
Dairy Products Price	-0.604	1.146
Fruits and Vegetables Price	-1.641	0.735
Non-Alcoholic Beverages Price	-0.705	0.737
Fuels and Related Products and Power		
Electricity Price	-0.243	0.466
Natural Gas Price	-1.199	0.112
Motor Fuel Price	-1.156	0.099
Fuel Oils and Other Fuels Price		

***, **, *: Significant at the 1%, 5% and 10% levels respectively

III

The War for Consumers' Minds and Wallets: State vs. Industry Responses on Cigarette and Petroleum Consumption

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Abstract

The main objective of this article is to examine the empirical effect of state and industry responses on consumption of cigarettes and petroleum in the United States from 1998-2012. Upon facing consumption choices, the consumer faces two competing sets of messages, one from the government and another from the industry. The objective of the state is to steer consumption in the right direction due to the harmful effects from consumption and asymmetric information among consumers. This is done mainly via taxation and state media expenditures. The industry, on the other hand, seeks to incentivize the public to ignore or reject state research and signals as well as maximizing net economic returns. This is mainly done via industry media and lobbying expenditures. We find that the main results indicate, for cigarettes, industrial media and lobbying expenditure is statistically significant on consumption. For petroleum, we find that producer prices, state media expenditure, and industrial lobbying expenditure are statistically significant on consumption. While significant results are mainly seen for media and lobbying expenditures, no significant results are seen for taxation.

Keywords: advertising; consumption; lobbying; prices; taxation; vector error correction model

JEL Classification System-Numbers: C22, D12, D72, D80, H23, I18, Q58

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CERE (Centre for Environmental and Resource Economics)
Graduate School in Population Dynamics and Public Policy

1. Introduction

The objective of this article is to examine the effect of state and industry responses, or measures, on consumption of cigarettes and petroleum in the United States from 1998-2012. Specifically, this paper looks at the effects of the government's responses to discourage overconsumption of these harmful goods through taxation and state media expenditures. We then examine the effects from the industry's response to the government, with the purpose to increase consumption, in the form of industry media and lobbying expenditures. The key contribution of this article is a combination of these types of state and industry communication, from many data sources, to examine the empirical effect on the consumer's consumption decision.

The two commodities considered are cigarettes and petroleum fuel. Cigarettes mainly produce negative private internalities affecting the consumer privately (e.g. health care costs)[2] whilst holding an additional feature of addictiveness. Petroleum on the other hand produces negative public externalities affecting the public collectively (e.g. pollution) whilst holding a feature of technical addictiveness[3].

Upon facing consumption choices, the consumer faces two competing sets of messages, one from the government and another from the industry producing the harmful commodity. The objective of the government is to steer consumption in the right direction to minimize costs to the consumer and the public. It is argued that it is irrational to consume a product that is bad for you or for the public good, and therefore many have hypothesized that the decision to consume, knowing these effects, may be based on imperfect information (Hu *et al.*, 1995a). This is due to that consumers hold only partial knowledge on the characteristics or consequences of consumption, as well as the state of the world and nature (Mathewson, 1972). There is then a case for the state to intervene to correct these market failures of asymmetric information and negative internalities/externalities. On the other hand, the industry's objective is to maximize net economic returns, which in turn motivates marketing and communication campaigns.

To affect consumer choice, both groups also seek to maintain and increase their information 'stock' that is perceived by the public. Hence, information potentially has a strong effect within consumption decisions of these commodities. The key feature of this article is to determine the long-term effects, given a wide variety of state and industry responses, on which responses cause the largest impact on consumer consumption. Through time-series expenditure data, this article will conduct analysis from the years 1998 to 2012.

The rest of the article is structured as follows. In section 2, we provide a detailed background to the problem underlying the analysis. In section 3, an outline of the model used for the empirical analysis as well as a description of the data is provided. Section 4 will present the results from the analysis while section 5 will provide concluding remarks and policy recommendations.

[2] It is also well known that cigarettes produce negative public effects through second-hand smoke and pollution.

[3] This means that it is difficult to switch between alternatives and habits.

2. Background and hypotheses

When considering governmental responses to consumption of commodities producing negative private and public externalities, the most popular policy lever of the state is excise taxation. This message is then reinforced by changing social norms through generating public support for control policies (e.g. tax initiatives and restrictions) as well as changing attitudes and beliefs towards consumption. It is argued that through changing these social norms, the government can validate or justify regulating a legal good, sustain decreasing consumption, and counter industry media responses (Jacobson *et al.*, 1997). This is often done through paid-for state media campaigns and research where the better informed government, through possession of statistical agencies along with specialized research groups, disseminates this information through mutual communication streams (Licari and Meier, 2000; Friend and Levy, 2002). Such state media campaigns can be public service announcements through various forms of media, discussions regarding research on consumption, and announced descriptions of legislative introductions.

For tobacco, results find that well-funded and implemented mass media campaigns, joined with comprehensive control programs, are associated with sustained reduced consumption (Friend and Levy, 2002). However, considering the case of tobacco, we have seen from recent years, that expenditures on tobacco control media campaigns have fallen[4] despite the Center for Disease Control recommending each state spend $1-$3 per capita to counter pro-tobacco influences and educate the public (CDC, 2004). Despite evidence for effectiveness, tobacco control media campaigns have proven difficult to sustain due to lack of spending and industrial counter-advertisements (Ibrahim and Glantz, 2007). Thus, this paper will analyze how effective media advertising has been.

State communication tackling petroleum consumption operates in a different nature than that of tobacco where advertisements do not directly ask consumers to simply stop driving or to stop buying fuel. However, research campaigns showing negative effects on the public good are communicated through various media outlets, government broadcasts, and via educational material. Furthermore, the government seeks to counter messages by the oil and gas industry who aim to downplay the severity of climate change[5]. Thus, this paper looks at expenditure on the U.S. Global Climate Change Research Program (USGCRP) as a measure of governmental media expenditure[6]. The need for expanded research and communication has been made clear to counter the oil industry, who have spent millions of dollars on ad campaigns belittling government research and attacking U.S. energy policies as being against economic growth and 'anti-jobs' (Colman, 2012). The importance of doing something is, as stated by Hmielowski *et al.* (2013), that remaining uninvolved gives climate contrarians the reins to redefine how the public thinks about climate change scientists and their research.

The main aim of industrial communication is to incentivize the public to ignore or reject state research and signals through various motivations. This is especially the case if the state's communication is uncomfortable to believe, i.e. if there is skepticism as to the severity of the negative effects from consumption. As stated by Warner (1985), the tobacco industry's media

[4] As of 2003, less than 3% of the potentially available $19 billion that states received from tobacco excite taxes and tobacco settlement money is used for tobacco control programs.

[5] As of 2013, only 63% of Americans believe that climate change is happening despite a large consensus of the scientific community stating that climate change poses serious risks to human societies and ecosystems, which have already begun to happen (Hmielowski *et al.*, 2013; Leiserowitz *et al.*, 2013)

[6] Details of and reasoning for using the USGCRP are provided in Section 3.2.

response has three key tactics: (1) Focus is given on the non-health attributes of smoking, such as flavor, satisfaction, sex appeal, and individuality; (2) Given the mass amount of scientific evidence against smoking, the tobacco industry uses these concerns to promote "less-hazardous products" to lower the concern and stigma to the public. Furthermore, as stated by Brownell and Warner (2009), to counter research on the harmful effects of tobacco, the tobacco industry is keen on labeling state research as 'junk science', and deny the addictive and destructive nature of smoking; (3) Lastly, the largest goal is to maintain or increase market expansion amongst new consumers and for those considering quitting. Due to the highly addictive nature of tobacco, it is vital that the industry gains new long-term customers in the face of government advertisements encouraging others to quit smoking.

As with tobacco, media campaigns for the petroleum industry also seek to counter bad publicity. One of the most important tactics for the petroleum industry is combating emission constraints and green legislation. As stated by Van den Hove *et al.* (2002), to achieve this and preserve the petroleum industry as one of the most financially and politically powerful sectors, three tactics are key: (1) The industry seeks to place priority on the business implications of decreased consumption on domestic jobs and business performance; (2) The petroleum industry aims to weaken perception that consumption is causing damaging climate change;[7] and (3) Lastly, priority is placed on labeling themselves as more 'environmentally friendly' with 'greener' methods of production. Due to previous oil spills, image-restoration media responses have been vital to show to the public that they are still responsible and to counter the growing anti-fossil fuel sentiment

Advertising from both industries may further common goals where government information campaigns may be seen as anti-business or holding potential political bias. Industry media campaigns may try and increase support for the domestic economy feeding opposition to alleged 'government interference' and defending the 'free-enterprise system' (Sutter, 2002).

Finally, the other major industry response considered in this article is the role of lobbying[8]. Where media expenditures are considered direct communication, lobbying may be considered to be an indirect form of communication seeking to persuade policymakers on what is good public policy. Specifically this includes influencing statements made by politicians and decisions on policy. The public is also made aware of these messages, through rules directing extensive disclosure, legislative decisions, and through politicians' statements and decisions[9]. This subject fits in with the field of political equilibrium theory and characteristics of basic signaling models in game theory (Brock and Magee, 1978; Kollman, 1998). This forms a traditional rent seeking view of lobbying as a straightforward *quid-pro-quo* exchange of money for political decisions. If the interests of the policymaker and the industry conflict, a strictly positive contribution is required to enhance the credibility of industry reports on the reasons they require support (Lohmann, 1995). A key dynamic of industrial lobbying is that such expenditures can be a long-term investment which may not bear fruit right away (Kang, 2011)

[7] This has been seen greatly in light of the 2010 BP oil spill in the Gulf of Mexico (considered the largest and most costly marine oil spill in the history of the petroleum industry) where massive fines were levied on BP and sweeping regulation was called for to prevent a future incident.

[8] Lobbying is defined as activity by special interests and industries to argue for specific legislation in the government.

[9] This may be in the form of political campaign speeches, statements on laws passed (or not passed), and organized messages to the public.

It is argued that many politicians have maintained the message from the tobacco and petroleum industries or reversed earlier held positions. Considering climate change, 2012 presidential candidate Mitt Romney in June 2011 stated, "[…] *I believe based on what I have read that the world is getting warmer, and number two, I believe humans contribute to that*". However, in October 2011, one might argue that Romney reversed his views stating, "*My view is that we don't know what's causing climate change on this planet, and the idea of spending trillions and trillions of dollars to try and reduce CO_2 emissions is not the right course for us*", whilst advocating aggressive oil production (Otto, 2012). Overall, the public may accept lobbying as benefiting the policymakers' work and avoiding bureaucratic errors. However, lobbying may instead have the opposite effect than intended due to the negative perception held by the public where these forms of contributions may be seen as another form of manipulation, corruption, or bribery.

Authors have extensively debated the effectiveness of the tobacco and petroleum lobbies. For example, it is argued that the power of the tobacco industry to sway politicians has decreased over the years where a growing number of people view tobacco lobbying efforts very negatively, and as public health programs have become more successful (Givel and Glantz, 2001; Trochim *et al.*, 2003). Politicians may also choose to ignore these industries in spite of their contributions due to the unfavorable association with the lobby and the social costs of increased consumption on negative externality producing commodities (Brock and Magee, 1978). For petroleum lobbying, many authors (Kolk and Levy, 2001; Gelbspan, 2004; Kolk and Pinkse, 2007) have noted that the effectiveness of lobbying has increased over the years in persuading the politicians and the public alike through claims that climate change science is exaggerated and that green policies will only hurt the economy. It is claimed that the result has been decreased legislation and taxes while maintaining high levels of consumption. From a study of lobbying in the energy sector, Kang (2011) states that environmental regulations also directly impacts the competitive advantage based on the current level of cleaner production technologies. Thus many companies in the energy industry seek to lobby the government. Here, the petroleum lobby forms the largest lobbyist spending group in Washington. This article will explore these claims and whether lobbying has had a net positive or negative effect on consumption.

Quite a few empirical articles have considered the subject of evaluating state or industry media advertising but few have considered empirically the effect of both on the state level (none on the national level). Hu *et al.* (1995a) studies state antismoking media campaigns against industry media campaigns on cigarette consumption in California from 1980 to 1993. Through quarterly data on cigarette consumption and taxes per pack of cigarettes, California's antismoking media campaign is measured in terms of media placement expenditures by the Tobacco Control Section in the California Department of Human Services. Furthermore, in Hu *et al.* (1995a), data on industrial media expenditure is obtained through quantifying total pages of cigarette advertising in Life magazine, distributed in California. Hu *et al.* (1995a) employs a time series model with explanatory variables including a time trend, quarterly dummy variables, California's state tax, the federal tax rate, retail price (minus state tax), as well as state and industrial media variables.

From Hu *et al.* (1995a), results show that the state media campaign has a statistically significant negative effect on cigarette consumption and the industry media campaign has a statistically significant positive effect on consumption. Other effects show that the state tax rate on cigarettes, the federal tax rate and time trend show statistically significant and

negative impacts on cigarette consumption. This study departs from Hu *et al.* (1995a), and expands upon it as it examines the effects of taxation and state media campaigns along with the industrial counterbalancing response on the federal level. A further key feature that this article will use an alternative methodological procedure to achieve these aims.

Another contribution that this study provides is that we expand upon previous empirical studies which have focused mainly on media advertising as the central form of communication without consideration for more implicit communication in the political field through lobbying. Hu *et al.* (1995b) alluded to the effects of lobbying by quoting Begay *et al.* (1993) that for California, lobbying efforts may have been cost-effective for the tobacco industry compared to countering the state's media campaign. This provides a potentially valuable research area to explore. Through much discussion on the importance and effectiveness of lobbying, lobbying is said to have a sporadic or unknown effect where, "*sometimes these campaigns have their effects – just as rain sometimes follows the rainmakers' dance*" (Kollman, 1998). However as Kollman (1998) states, most of the conclusions of the influence of contributions may have something to do with the lack of research on this topic which shows the importance of such a study in this article.

Furthermore, while many have explored the effect of state research and industrial media advertising concerning petrol, there have been no articles to the author's knowledge which have empirically considered the effects together. Much literature (Levy and Newell, 2000; Levy, 2005) has alluded to the fact that more studies should be conducted to analyze the effects of state and industry responses to climate change, which forms a central part on the U.S. climate change strategy.

The key contribution of this article is that we attempt to bring together, through a wealth of data sources, the effects on consumption from state and industry media expenditures as well as the effects on lobbying from the tobacco and petroleum industries.

3. Methodology

This section details the model and provides a description of the data used in the empirical analysis. The underlying framework for the econometric model is that consumers base their consumption decision on their preferences for goods and their budget constraint, given the information they have on the characteristics of the goods. This means we may model consumer demand as a function of prices, income and consumers' knowledge about the characteristics of the good. Paramount to this study is that we allow consumers' perception about the characteristics of the good to be affected directly by information campaigns by the state, marketing campaigns by the industry and indirectly through industry lobbying as discussed above. To accomplish this, this paper employs a Vector Error Correction Model (VECM) approach as originally employed by Davidson *et al.* (1978), Hendry and von Ungern-Sternberg (1981), and Salmon (1982). The advantage of using a VECM model, as opposed to a standard Error Correction Model (ECM) is that there is less uncertainty of directional causality between variables. This is especially the case where there are more than two variables under consideration.

3.1 Modeling approach

Not many topics in economics are longer or deeper than the literature on the household's decision to consume or save their available income. We know that prices are a key part of

influencing consumption as the price effect directly impacts the budget constraint where typically we would expect that an increase in price would lead to a fall in consumption. These consumer prices consist of the producer price from the industry and taxes added by the state. Income is another key factor affecting consumption. As a consumer's budget constraint would rise, due to an increase in disposable income, the consumer is able to consume more. This is especially the case for luxury items which may impact consumption of other substitute items.

However, alongside variables directly influencing the consumer's budget constraint are exogenous vectors from other sources which affect the information stock or welfare function of the consumer. For the state, as their goal is to reduce consumption of cigarettes and petroleum, it is key for the state to control the narrative on how the public perceives the product's impact on the public and private good. In this article, this is done primarily through state paid media expenditures to educate the public on the negative effects of consuming cigarettes and petroleum. Through increasing this information, the welfare effect from consumption would be, in theory, lessened where a negative effect would be reinforced in the consumer's information set.

On the other side, the industry seeks to counter these messages by the government to improve their own financial performance through increased or sustained consumption. Industrial media advertisements would seek to promote use through convincing the public that the negative effects from consumption are not that great. Additionally for tobacco industries, these advertisements seek to promote enjoyment of smoking to fuel addiction. To counter political messages, through implicit communication, industrial lobbying also aims to promote consumption through lobbying politicians. This would be through state messages, controlling the narrative and countering taxation increases. Each industrial communication method would have the aim to increase welfare from consumption and decreasing the information stock from the government. Hence an increase in these measures would in theory be expected to raise the level of consumption.

As mentioned in previous sections, it is appropriate to consider information from media campaigns, lobbying and political contributions as having a cumulative information effect as a stock variable, as opposed to the traditional flow-variable concept. A consensus of previous studies (Hamilton, 1972; McGuiness and Cowling, 1975; Baltagi and Levin, 1986) has stated that this is a relevant assumption as advertising takes time to achieve the intended effects on providing missing information to the consumer. In the long-run, these stock effects, and issues of depreciation of these stock effects, are implicitly included within the model.

Given the basic framework described above, the demand function for a particular good can be expressed as:

$$C = f(P, T, GM, IM, LOB, GDP) \tag{1}$$

where C denotes consumption of cigarettes or petroleum; P denotes the producer price; T denotes the excise tax rate; GM denotes state media expenditure; IM denotes industry media expenditure; LOB denotes industry lobbying expenditure; and GDP is a proxy for income. This essentially shows that consumption is a form of prices, income and various exogenous factors that are assumed to affect the consumer's information set concerning the good, hence affecting their preferences for the good.

Since the underlying framework for the empirical analysis is a VECM, we start by considering a reduced-form VECM model with K variables expressed as in (2):

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{\rho-1} \Delta y_{t-\rho+1} + u_t \quad (2)$$

where $y_t = (y_{1t}, \ldots, y_{Kt})'$ is a $(K \times 1)$ vector, which is defined as $y = \{C, P, T, GM, IM, LOB, GDP\}$; for Γ_i, $i = 1, \ldots, \rho - 1$ are $(K \times K)$ short-run coefficients where ρ denotes the terminal period or how many lags are included in the analysis; Π is a $(K \times K)$ matrix containing the loading matrix coefficients α and cointegration vectors β, where both α and β are of dimension $(K \times r)$ and a rank r. Lastly, $u_t = (u_{1t}, \ldots, u_{Kt})'$ denotes a K-dimensional white noise process where $E(u_t) = 0$, $E(u_t u_t') = \Sigma_u$, and $E(u_t u_s') = 0$ for $s \neq t$. We have that the covariance matrix (Σ_u) is assumed to be non-singular if not otherwise stated. For a further derivation, please see Appendix A. As a result, short-run coefficients are given across each variable and for each variable. However, to get long-term coefficients for consumption, which is set as the dependent variable, separate equations form the variables in the system of equations are normalized on consumption to get the cointegrating vector.

The next step in the empirical methodology is to test for unit roots in the time series variables due to the concern of spurious regressions and its importance in the time series literature, especially variables with trending behavior which is common in economic variables, especially macro variables. It is important to know if the variables are stationary or trending and whether they are cointegrated if trending in order to propose the appropriate econometric method for the analysis. If the statistical characteristics of the time series, such as mean and variance, are constant over time, this implies a stationary process. To test for stationarity of our variables, the Augmented Dickey-Fuller test is implemented. The basic form of the Augmented Dickey-Fuller (ADF) test is given by the following equation on a variable with a constant term and trend:

$$\Delta y_t = \sigma + \beta T + \delta y_{t-1} + \gamma_\rho \sum \Delta y_{t-\rho} - u_t \quad (3)$$

where σ denotes the constant term; βT denotes the trend; and u_t denotes the error term. The ADF test hence includes the augmentation terms which are the lag terms of the dependent variable. Here the null hypothesis, H_0, is that $\delta = 0$ implying a unit root. The alternate hypothesis, H_A, is that $\delta \neq 0$ implying stationarity.

If the unit root test reveals non-stationary series or a mixture of I(0) and I(1), it is then important to test for long-run relationship between the series in the model to avoid estimating a spurious regression. To determine the number of cointegrating equations in a vector error correction model, this study uses the Johansen test for cointegration. This is based on the study by Johansen (1995) which implements three types of methods for determining the number of cointegrating equations, or rank (r). The first method being Johansen's "trace" statistic method; the second is the "maximum eigenvalue" statistic method; and the third method selects r to minimize an information criterion. The null hypothesis of the trace statistic is that there are no more than r cointegrating relations. By restricting the number of cointegrating equations to r, this implies that the remaining eigenvalues are zero. This is shown by equation (4)[10]:

[10] As explained in Johansen (1995, chapters 11-12)

$$-T \sum_{i=r+1}^{K} \ln(1 - \hat{\lambda}_i) \tag{4}$$

where T is the number of observations and $\hat{\lambda}_i$ are the estimated eigenvalues. For any given value of *r*, large values of the trace statistic are evidence rejecting the null hypothesis that there are *r* or fewer cointegrating equations.

In the case that no cointegration is discovered, alternative methods can be used to establish links between variables. Methods such as the Vector Autoregression (VAR) model with Granger causality tests may be used. This test is detailed further by Engel and Granger (1987) and Lütkepohl (2006). If we may detect cointegration within our time series, this implies that that there exists a long term relationship between them where we may apply the Vector Error Correction Model (VECM) to evaluate the long-run effects (and short-run properties) of the cointegrated series.

3.2 Description of the Data

This paper uses readily available quarterly time series data covering the years 1998-2012 from various data sources for the United States. The reason why the United States is chosen is that certain data on lobbying and media expenditures is easier to obtain for the United States than for Europe. Considering the data required, we do not look on the state-by-state level as much of the data is incomplete or unobtainable and thus we look to avoid an incomplete study. Lastly, we begin from the year 1998 as this is the first year that data on lobbying is available on the public record.

Consumption for tobacco is calculated as cigarettes consumed per capita whilst petroleum products are consumed per barrel (thousands) and per capita. These values are taken per capita to account for changes in the population. Population data is given by the United States Census Bureau. Quarterly values for cigarette consumption (per unit) are taken from the Alcohol and Tobacco Tax and Trade Bureau in the Department of the Treasury. We count cigarettes only as data on other forms of tobacco is not readily available for the timeline to the author's knowledge. As other forms of tobacco (chewing tobacco, snuff, etc.) form a small fraction of the total tobacco consumption, this should not lead to any estimation errors. Petroleum consumption (in thousand barrels per day) refers specifically to distillate fuel oil and liquefied petroleum gases. Quarterly consumption data for this is given by the US Energy Information Administration (EIA). From Appendix B in Tables 1.1 and 1.2 for tobacco and petroleum, respectively, we see that consumption of cigarettes has steadily decreased over time at almost a constant rate. For petroleum, following an increase in consumption from 1998-2000, we see a steady decline in consumption on average.

Quarterly data for price is given by the producer price for cigarettes and petroleum excluding federal taxes in current prices. This producer price data is given as indices taken at the national or federal level where producer prices do not vary state by state. This is the most convenient method given availability of the data. This data is obtained from the United States Department of Labor Bureau of Labor Statistics (BLS). We see in Table 2.1 (Appendix B) for tobacco that producer prices seem to have steady climbed over time. For petroleum, in Table 2.2, producer prices have risen at a greater level over time apart from a drop in prices in 2009. Tobacco excise tax, measured in cents per pack of 20 cigarettes, is obtained quarterly from the average across all fifty states. This data is obtained from the Department of Health and Human Services Centers for Disease Control and Prevention (CDC). Likewise, the same

principle is done for excise tax on petroleum products where quarterly data is obtained as an average across all states but measured in cents per gallon. This data is obtained from the U.S. Department of Transportation Federal Highway Administration (FHWA). We see in Table 3.1 (Appendix B) for tobacco that taxes rose at a gradual rate from 1998 to 2001 but rose quicker from 2002 to 2010 before slowing down again after. For petroleum, in Table 3.2, we see a steady increase in taxes over time on average, but less of an increase over time than for tobacco.

GDP measures, controlling for income are also included to detail how the income of a country may affect consumption. Data for GDP levels (measures in billions US$) was provided by the U.S. Bureau of Economic Analysis.

This article provides two separate measures for state advertising spending on tobacco and petroleum. As monetary variables it is appropriate to deflate these variables based on the current level of consumer prices and thus we use the quarterly U.S. Consumer Price Index (CPI) (1997 = 100) given by the BLS. Tobacco industry state advertising spending is provided annually by the Campaign for Tobacco-Free Kids database on state spending vs. tobacco industry marketing. From Appendix B, Table 4.1, we see that state expenditures on media have had an irregular pattern, as it rose sharply from 1999 to 2000. However, since then, media expenditures have, on average, fallen.

As mentioned for state ad spending concerning petroleum[11], the nature of advertising spending is not as it is with tobacco. Instead, we use data provided for the U.S. Global Climate Change Research Program (USGCRP) on research and transmission of results through various outlets as a measure of the state response. Data for the USGCRP is provided by the U.S. Global Climate Change Research Program[12] where financial reports are released annually. The USGCRP was established as described in the Global Change Research Act of 1990. Through thirteen agencies in the government, the USCGRP conducts research and trends on the level of climate change from energy use while providing suggestions on how to mitigate these problems. The final goal of the USGCRP is to communicate and educate to broaden public understanding of climate change through: (1) strengthening communication and education research; (2) reach diverse audiences; (3) increase engagement by the public; and (4) cultivate the scientific workforce. From Appendix B, Table 4.2, we see that state expenditures on media show, as for tobacco, a very irregular pattern. However, on average we see that there is a decrease in expenditures over time.

Considering industry media expenditures, as monetary variables these are again deflated by the quarterly US CPI index. Tobacco industry ad spending is provided annually by the Campaign for Tobacco-Free Kids database on state spending vs. tobacco industry marketing. We see from Table 5.1 in Appendix B that industry media expenditures on tobacco rose steadily from 1998 to 2003. However, since 2004, media expenditures have been gradually decreasing to a final position less than that in 1998.

Comprehensive and consistent quarterly data on petroleum industry media expenditures is, however, particularly difficult to obtain and not readily available. Thus, a measure for media expenditures is done via proxy as explained. As suggested by the Union for Concerned Scientists, on average the petroleum industry spends 8% of its total profits on advertising and

[11] See Section 2

[12] U.S. Global Climate Change Research Program - http://www.globalchange.gov/home

marketing. Using this benchmark, may not be a fully accurate representation of advertising spending but holds as an approximate figure for this study. Data on profits is given annually by the IEA (International Energy Agency). Using a sensitivity analysis, by altering marginally the percentages spent on petroleum industry advertising by 2% in either direction, it is found that these changes do not alter the significance of our results for our main variables of interest. Thus we can say that this benchmark for petroleum industry advertising may be an appropriate proxy. We see from Table 5.2 in Appendix B that industry media expenditures on petroleum have on average increased sharply from 1998 to 2007. Since 2008, following a political regime change, expenditures dropped sharply from 2008 to 2009 before increasing sharply again in 2010. However, since 2011 expenditures have dropped once more to levels less than what was seen in 2004.

Quarterly data on lobbying was provided from The Center for Responsive Politics and checked against records provided by the U.S. Federal Commission from 1998 to present date. Due to data restrictions, lobbying data from 1998 to 2007 was provided on a mid-year and year-end basis before quarterly reports were published. A figure of lobbying trends from 1998-2012 can be found in Appendix B for the tobacco industry (Figure 6.1) and the petroleum industry (Figure 6.2). Here, we see that the tobacco industry has seen lobbying fall where in the (first quarter) the tobacco industry was the largest lobbying industry at $24.5 million and in 2012 (fourth quarter) the amount was lower at $6.6 million. This big drop in lobbying expenditures from 1998 to 2000 can be attributed to massive fines and settlements costing the industry billions of dollars as the tobacco industry became a prime target for many citizen groups and politicians (LaRussa, 2010). However, since 2000, tobacco lobbying expenditure has not changed dramatically.

However, for petroleum industry lobbying (Table 6.2), expenditures have grown quite dramatically from $15.8 million in 1998 (first quarter) to $36.5 million in 2012 (fourth quarter) with a long history of strong influence in Washington. Before, 2008, petroleum lobbying has remained fairly constant. It is argued that from the start of the presidency of George W. Bush in 2000, policymakers have oft sided with and been lobbied by the petroleum industry where a considerable number of groups ranging from journalists, scientists, federal policymakers and advocacy organizations have viewed the Bush administration as hostile to climate policy (Dunlap and McCright, 2008). As stated by Lee *et al.* (2001), within the first two months of Bush's presidency, he announced that his administration would not support regulation of carbon dioxide or pursue ratification of the Kyoto Treaty. Furthermore it was illuminated in June 2005 by Andrew Revkin of the New York Times that Philip Cooney, a lawyer and lobbyist for the American petroleum industry, was tapped by the Bush administration as head of the climate unit of the White House Council on Environmental Quality. Following this, he has been reported to have made a number of word changes to summaries of scientific documents to exaggerate its scientific uncertainties and remove definitive statements on the known impacts of global warming before resigning and taking a job with Exxon-Mobil (Gelbspan, 2004).

4. Results

This section details the results from estimation of our empirical model described in Section 3. The key point of this analysis is to estimate the effects of state vs. industry responses on quarterly per capita consumption. To determine whether we may proceed with the Vector

Error Correction Model (VECM) approach, we first conduct a stationarity test as detailed in the Methodology section through the Augmented Dicky-Fuller (ADF) test. Results from the ADF test for cigarettes and petroleum are presented in Appendix C, Table 1:

As shown in Table 1, for cigarettes we may reject the null hypothesis of a unit root at the 1% level for price and lobbying. For petroleum we may reject the null hypothesis of a unit root at the 1% level for consumption and lobbying. However it is clear from Table 1 that we may reject the null for all variables at their first differences at the 1% significance level for both cigarettes and petroleum. This implies that all variables are integrated at I(1), except price and lobbying in the case of cigarettes that are I(0) as well as consumption and lobbying for motor fuel that are I(0).

Next to determine the optimal number of lags, the selection order criteria is also calculated through the Final Prediction Error (FPE), Akaike's Information Criterion (AIC) and the Hannan and Quinn Information Criterion (HQIC) and Schwarz's Bayesian Information Criterion (SBIC). An advantage of the AIC specification is that it is asymptotically normal in selection the model with the least mean squared error (Yang, 2005). The advantage of the SBIC specification is that it is better suited for quarterly data with a sample size of fewer than 120 quarters with a greater power of estimation (Sheppard, 2010). To determine the optimal number of lags we look for what is the number of lags commonly specified by the majority of the specification tests. Results for the lag-order selection criterion are presented in Appendix C, Table 2.1 for Cigarettes and Table 2.2 for Petroleum. From these results, significance is achieved at lags of order 4. Thus, we proceed with further tests with lags (4) despite results from the SBIC specification which has significance at order 1.

Next, we conduct cointegration tests, as described in Section 3 (though the Johansen test for cointegration). Results are shown in Appendix D for cigarettes (Table 1.1) and petroleum (Table 1.2) to determine the rank, or number of cointegrating equations. Here the first null hypothesis is that there exists no cointegration among the variables ($H_0: r = 0$). If this is rejected we repeat for $H_0: r = 1$. The process is continued until we cannot reject the null hypothesis at a certain rank; at this point, that value of r is the commonly-used estimate for the number of cointegrating relationships. From Table 2a, for cigarettes, $H_0: r = 1$ is not rejected at the 5% critical value ($22.9273 < 29.68$). This implies that the trace statistic result does not reject the null hypothesis that the variables of interest are not cointegrated. The final number of cointegrating equations with four lags (as specified earlier) is equal to one. The same result is seen for petroleum where $H_0: r = 1$ is not rejected at the 5% critical value ($21.2544 < 29.68$). This implies the presence of cointegration for at least one vector among the variables for both cigarettes and petroleum. Thus, we may use the VECM model approach for estimation.

As we have seen the presence of cointegration between our variables, this suggests a long-run relationship among the variables of interest. Below, results for the VECM estimations can be seen for cigarettes (Table 1) and petroleum (Table 2). As our focus is on the long-run effects, we do not consider the short term variables, but rather the long-run elasticities. All variables are in logarithmic form within the VECM model. In order to get one set of results, as said in the methodology, separate equations for the variables in the system of equations are normalized on consumption (the dependent variable) to get the cointegrating vector. In these tables, the coefficients can be seen as long-run coefficients together with a constant tern as denoted by "_cons".

Table 1: Vector Error Correction Model - Cigarettes

Cointegrating equations:

Equation	Parameters	Chi2	P > chi2
_ce1	7	1910.305	0.0000

Beta	Coeff.	Std. Error	z	P > |z|	[95% Conf.	Interval]
C	1	.	.	.	.	.
P	0.1179	0.0916	1.29	0.198	-0.0615	0.2974
T	0.1077	0.0708	1.52	0.128	-0.0311	0.2466
GM	0.0428	0.0382	1.12	0.263	-0.0321	0.1178
IM	**-0.4706*****	0.0388	-12.12	0.000	-0.5467	-0.3945
LOB	**0.1840*****	0.0384	4.79	0.000	0.1088	0.2592
GDP	0.1731	0.1872	0.92	0.355	-0.1939	0.5400
_cons	-18.0961	.	.	.	.	.

****, **, *: Significant at the 1%, 5% and 10% levels respectively*

In Table 1, for cigarettes, we can see that the variables for producer price (P), taxation (T), government media expenditure (GM), and income (GDP) are not significant in our analysis. However, there appears that there is significance for industrial media expenditure (IM) and industrial lobbying expenditure (LOB), both at the 1% level. A unique result of this study is that industrial media expenditure is not of the expected sign. Here an increase in industrial media expenditure of 1% is associated with a fall in consumption at -0.471%. However, lobbying expenditure is of the expected sign where a 1% increase in lobbying expenditure is likely to be followed by an increase in consumption by 0.184%.

Table 2: Vector Error Correction Model - Petroleum

Cointegrating equations:

Equation	Parameters	Chi2	P > chi2
_ce1	6	392.2281	0.0000

Beta	Coeff.	Std. Error	z	P > |z|	[95% Conf.	Interval]
C	1	.	.	.	.	.
P	**-0.1667***	0.0969	-1.72	0.086	-0.3566	0.0233
T	-0.6242	1.6754	-0.37	0.709	-3.9080	2.6596
GM	**-0.5227*****	0.0783	-6.68	0.000	-0.6761	-0.3693
IM	0.0162	0.0468	0.35	0.728	-0.0754	0.1079
LOB	**0.4803*****	0.0534	9.00	0.000	0.3757	0.5849
GDP	0.5281	0.3572	1.48	0.139	-0.1720	1.2282
_cons	-10.4149	.	.	.	.	.

****, **, *: Significant at the 1%, 5% and 10% levels respectively*

For petroleum, in Table 2, we see that government media expenditure (GM) and industrial lobbying expenditure (LOB) is significant at the 1% significance level. Producer prices (P) is also significant but at the 10% level. Unlike the results obtained for cigarettes, all coefficient values seem to be of expected sign. For an example, a 1% increase in price and government media expenditure would be likely to be followed by a decrease in consumption of -0.167% and -0.523%, respectively. However, a 1% increase in industrial lobbying expenditure would likely be followed by an increase in consumption of 0.480%.

Following estimation, it is appropriate to test for stability of the time series. This is appropriate where small changes in the time series lead to less amounts of variation within the analysis. From this, small changes in the variables will lead towards equilibrium and not away from it. Generally, model instability makes it very difficult to interpret regression results. To accomplish this, we employ an eigenvalue stability condition test in our vector error-correction model as developed by Engel and Granger (1987). A graph and is produced for roots of the companion matrix, as shown in Appendix E for cigarettes and petroleum in Figure 1.1 and Figure 1.2, respectively. Points that fall within the confidence bounds of the eigenvalue stability condition are considered stable where points outside are considered unstable. As we can see below, all variables fall within the confidence bounds and thus the model can be deemed stable. As model stability is equivalent to parameter stability, this implies that the model employed is invariant to possible policy interventions or "regime shift". Stability assumes a satisfactory degree of locally optimal power and a low probability of model misspecification (Hansen, 1992).

5. Conclusion

From the results presented, we are hence able to see clear policy recommendations for the state in order to counter the tobacco and petroleum industries for incentivizing sustained decreases in consumption. For cigarette and petroleum consumption, we have seen that through a lack of significant results, taxation has not been as effective, as hoped for, as a policy lever to affect the budget constraint of the consumer. While we still achieve a negative effect from price and tax effects in our model for petroleum, a slight positive result is achieved on cigarette consumption. Here, addictiveness may play a big role in cigarette demand. This may indicate to us that the consumers may be more responsive to price changes on petroleum products. Producer prices, as opposed to taxation, do have a significant and negative impact on consumption. Overall, these results may indicate to us that taxation may not be as effective as the other variables in influencing consumption behavior. Taxation, however, does hold a negative effect and despite these results, this does not mean that decision makers should abandon or decrease the level of taxation as taxation still has an effect on consumption as a vital policy lever.

Furthermore, direct communication through government media campaigns seems to have different results for cigarettes and petroleum. Government media campaigns on cigarettes are not significant in result and hold a slight positive value on consumption. Whilst this may be the case, it is still vital for the state to increase media advertisements where industry media spending has outnumbered state spending. As industrial media spending has increased, this may have shrunk the state's market share in communication. This seems to contradict the results from Hu *et al.* (2005a) during the timeline of 1980-1993. This may indicate that there should be a renewed focus on media spending alongside education to further the impacts from media expenditure.

For government media campaigns on petroleum, however, we do find significant results in the expected negative direction on consumption. Furthermore this elasticity value (-0.523%) is highest among the variables considered which implies that this form of communication has been successful in communicating messages to the consumer. This would indicate that the research campaign, the USGCRP, has been a valuable policy tool in communicating the effects of overconsumption of petroleum on the environment. This would be an encouraging

sign that the public does seem to react to messages of climate change and pollution, which has been a course of great debate regarding the relevancy of the USGCRP. Hence, a policy recommendation would be an extension of funding into the program and an expansion of the program across the country.

Contrasting results are also found regarding industrial media expenditures. For tobacco, we see that a negatively significant effect is found from media advertisements on consumption. This is not the expected sign we would expect where it appears that the public may be resistant to messages from the tobacco industry. Reasons for this might be that there may be potential backlashes of advertising due to an increased knowledge of the effects of smoking or that such advertisements may be read by children. Also, the effect of increasing media expenditure isn't resonating in the consumer's information set as it has previously. This may be encouraging that, although no significant result was found through state advertising expenditures, industry media campaigns have not only failed to eat into the state's market for consumer knowledge but also seems to have the opposite effect intended.

Considering industrial media expenditure for petroleum, a positive result on consumption was seen but at an insignificant level which shows that the industry's attempt to display themselves in a socially responsible light (i.e. through "greener methods" and with greater safety controls to prevent oil spills) has not appeared to resonate with the public. Coupled with significant results from state media expenditures in the expected direction, this appears to a good result for the state where policy for direct communication has been effective.

Finally, for industrial lobbying expenditures on tobacco, we see a consistent statistically significant positive effect on consumption. This seems to be a surprising result for tobacco and a worrying outcome as this indicates that lobbying has resonated largely with the public. Also, industrial influence via the political channel has not been negatively affected which contradicts earlier assertions (Givel and Glantz, 2001; Ahrens *et al.*, 2011) on the scope of the tobacco lobby's influence where because of the poor public image the lobby holds, tobacco lobbying may not be largely effective. While many policymakers may seek to hold high public credibility and pursue anti-tobacco policies due to increasing information regarding the negative effect from smoking, the threat to the economy and public health cannot be overstated. A policy suggestion may be greater efforts to counter the influence of tobacco lobbyists in Washington.

Petroleum industry lobbying also holds a statistically significant positive effect on consumption whereby with campaigning through the government, these messages seem to resonate with the public. This furthermore confirms literature that petroleum lobbying has positive effects on consumption (see, e.g., Kolk and Levy, 2001; Gelbspan, 2004; Kolk and Pinkse, 2007). This appears to be a discouraging result where, despite increased goals by the current Obama administration to reduce greenhouse gas emissions by 17% by 2020[13], progress has been quite slow. Climate change denialism still appears to be a rampant problem in the U.S. Congress[14], where 161 elected officials from the 113th Congress (Jan-June 2013) have taken in over $54 million from the fossil fuel industry to vote against 'green policies' despite an overwhelming scientific consensus on the environmental and financial impacts of climate change[15] (Germain *et al.*, 2013; Spross, 2013). Furthermore, so-called

[13] World Resources Institute, http://www.wri.org/project/us-climate-action
[14] Especially among the Republican Party where 90% of Republicans in the U.S. Congress deny climate change
[15] The United States in 2012 suffered $199 billion in economic losses due to extreme weather.

'attacks on the petroleum and oil industries' have been referred to as hurting U.S. jobs and against free market principles. This also may have had an impact over time on the effectiveness of state media campaigns to educate and inform the public where a growing proportion of the voting public also see media coverage as being exaggerated (Dunlap and McCright, 2008). These implications stress the importance of maintaining the stock of information to the public on the effects of climate change through media spending and the need to counter petroleum industry lobbying. Alternatively, the government may consider stricter legislation (e.g. spending limits) on lobbyists to curb influence.

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Appendix A

Here, individuals would be of order 0 or 1, such that the K-dimensional *VAR(p)* process given by equation (5) is called cointegrated of rank *r* if:

$$\Pi \coloneqq -\left(I_K - A_1 - \cdots - A_p\right) \tag{1}$$

has rank *r*, where Π is denoted as a matrix product $\alpha\beta'$ with α and β being of dimension $(K \times r)$ and of rank *r*. The identity matrix is denoted by *I*; Matrix α is denoted as the loading matrix which measures the average speed of convergence towards the long-run equilibrium. The matrix β is denoted as the cointegration matrix containing a matrix of cointegrating vectors. Thus, the long-run equilibrium relation can be written as:

$$\beta' y_t = \beta_1 y_{1t} + \cdots + \beta_K y_{kt} = 0 \tag{2}$$

where $\beta = (\beta_1, \dots, \beta_K)'$. Assuming that the equilibrium relationship between two variables, for example, is given by $y_{1t} = \beta_1 y_{2t}$, if changes in y_{1t} depend on the deviation from this equilibrium, in period $t-1$, we have that:

$$\Delta y_{1t} = \alpha_1\left(y_{1,t-1} - \beta_1 y_{2,t-1}\right) + u_{1t} \tag{3}$$

Similarly for the second variable, a similar relationship holds:

$$\Delta y_{2t} = \alpha_2\left(y_{1,t-1} - \beta_1 y_{2,t-1}\right) + u_{2t} \tag{4}$$

Thus for a general error correction model, given by previous literature (see, e.g., Davidson *et al.*, 1978; Hendy and von Ungern-Sternberg, 1981; Salmon, 1982), Δy_{it} additionally depends on previous changes in both variables as given by the following model:

$$\begin{aligned} \Delta y_{1t} &= \alpha_1\left(y_{1,t-1} - \beta_1 y_{2,t-1}\right) + \gamma_{11,1}\Delta y_{1,t-1} + \gamma_{12,1}\Delta y_{2,t-1} + u_{1t} \\ \Delta y_{2t} &= \alpha_2\left(y_{1,t-1} - \beta_1 y_{2,t-1}\right) + \gamma_{21,1}\Delta y_{1,t-1} + \gamma_{22,1}\Delta y_{2,t-1} + u_{2t} \end{aligned} \tag{5}$$

Having that all variables are $I(0)$ or $I(1)$, in this case all terms in equation (5) involving Δy_{it} are stable and that u_{1t} and u_{2t} are white noise errors which are also stable. Given that Π is denoted as a matrix product $\alpha\beta'$, in vector and matrix for and notation, equation (5) can be rewritten as:

$$\Delta y_t = \boldsymbol{\alpha\beta}' y_{t-1} + \Gamma_1 \Delta y_{t-1} + u_t \tag{6}$$

where $y_t \coloneqq (y_{1t}, y_{2t})'$; $u_t \coloneqq (u_{1t}, u_{2t})'$; $\boldsymbol{\alpha} \coloneqq \begin{bmatrix}\alpha_1 \\ \alpha_2\end{bmatrix}$; $\beta' \coloneqq (1, -\beta_1)$; and $\Gamma_1 \coloneqq \begin{bmatrix}\gamma_{11,1} & \gamma_{12,1} \\ \gamma_{21,1} & \gamma_{22,1}\end{bmatrix}$.

Overall, the Vector Error Correction Model (VECM) specification is written as:

$$\begin{aligned} \Delta y_t &= \boldsymbol{\alpha\beta}' y_{t-1} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{\rho-1}\Delta y_{t-\rho+1} + u_t \\ &= \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \cdots + \Gamma_{\rho-1}\Delta y_{t-\rho+1} + u_t \end{aligned} \tag{7}$$

Appendix B

Figure 1.1: Tobacco Consumption (Cigarettes per capita)

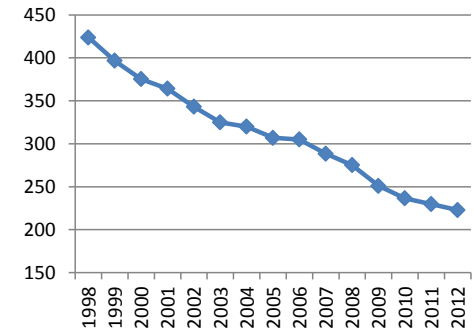


Figure 1.2: Motor Fuel Consumption (Thousands of barrels per capita)

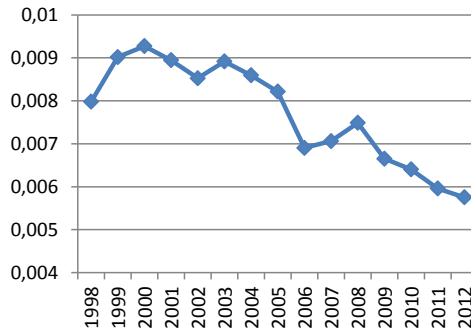


Figure 2.1: Tobacco Prices

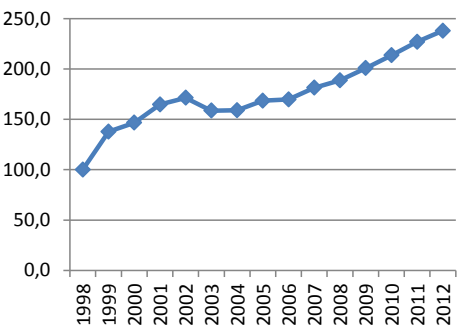


Figure 2.2: Motor Fuel Prices

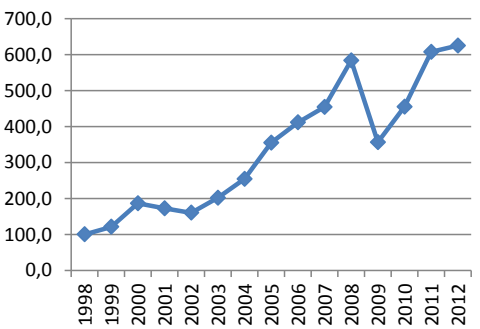


Figure 3.1: Tobacco Taxes

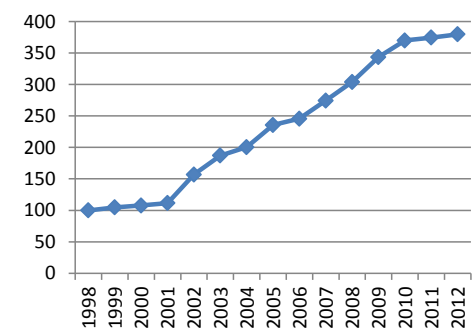


Figure 3.2: Motor Fuel Taxes

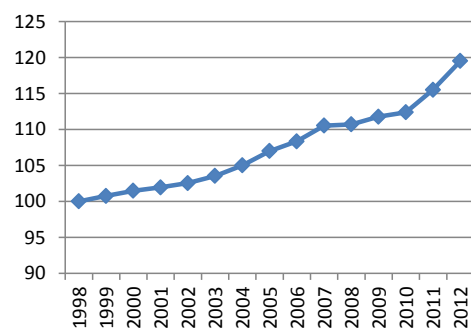


Figure 4.1: State Tobacco Media Expenditures (US$)

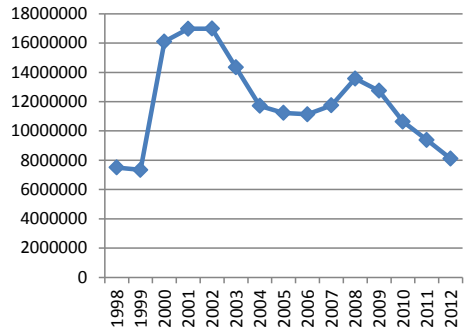


Figure 4.2: State Petroleum Media Expenditures (US$)

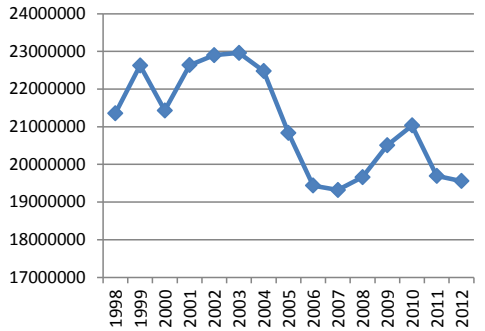


Figure 5.1: Tobacco Industry Media Expenditures (US$)

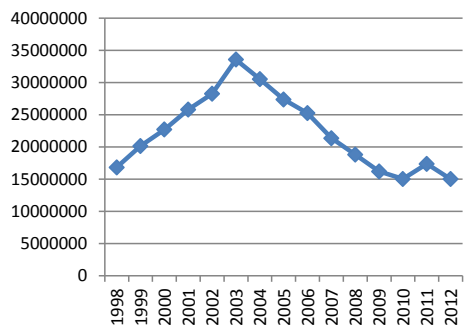


Figure 5.2: Petroleum Industry Media Expenditures (US$)

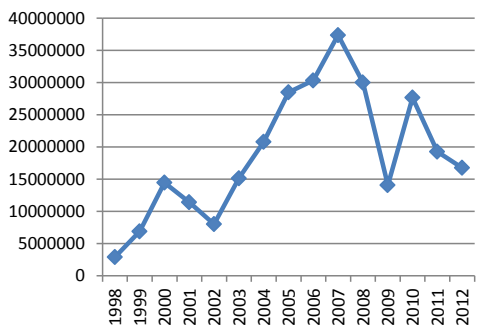


Figure 6.1: Tobacco Industry Lobbying (US$)

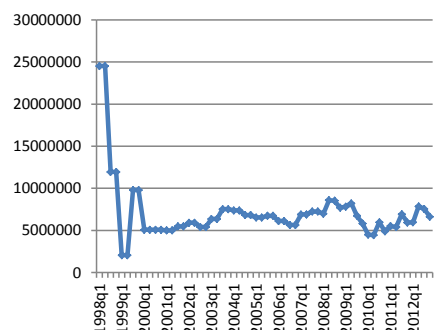
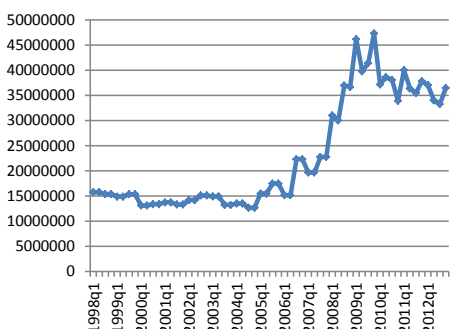


Figure 6.2: Petroleum Industry Lobbying (US$)



Appendix C

Table 1: Augmented Dickey-Fuller unit root tests:

	Cigarettes		**Petroleum**	
Variable	**Level**	**First difference**	**Level**	**First difference**
CONS	-1.281	**-9.855*****	**-4.708*****	**-8.278*****
P	**-3.884*****	**-5.143*****	-1.231	**-6.056*****
T	-0.846	**-8.562*****	0.739	**-9.089*****
GM	-1.094	**-7.564*****	-1.822	**-7.288*****
IM	-0.668	**-7.640*****	-2.690	**-7.696*****
LOB	**-5.100*****	**-7.607*****	**-3.805*****	**-9.535*****
GDP	-2.810	**-4.005*****	-2.810	**-4.005*****

****, **: Significant at the 1% and 5% levels respectively*

Table 2.1: Selection order criteria - Cigarettes

Lag	**LL**	**LR**	**df**	**p**	**FPE**	**AIC**	**HQIC**	**SBIC**
0	263.17				2.5e-13	-9.149	-9.051	-8.896
1	669.624	812.91	49	0.000	7.3e-19	-21.915	-21.130	**-19.890***
2	764.413	189.58	49	0.058	1.5e-19	-23.551	-22.078	-19.753
3	816.793	104.76	49	0.000	1.7e-19	-23.671	-21.512	-18.102
4	906.35	179.12*	49	0.000	**6.3e-20***	**-25.120***	**-22.273***	-17.778

Table 2.2: Selection Order Criteria – Petroleum

Lag	**LL**	**LR**	**df**	**p**	**FPE**	**AIC**	**HQIC**	**SBIC**
0	304.482				5.7e-14	-10.624	-10.526	-10.371
1	665.333	721.7	49	0.000	8.5e-19	-21.762	-20.977	**-19.737***
2	751.578	172.49	49	0.000	2.4e-19	-23.092	**-21.620***	-19.295
3	818.960	134.76	49	0.000	1.6e-19	-23.749	-21.589	-18.179
4	884.542	131.16*	49	0.000	**1.4e-19***	**-24.341***	-21.494	-16.999

Appendix D

Table 1.1: Johansen test for cointegration – Cigarettes

Maximum Rank	Parameters	LL	Eigenvalue	Trace statistic	5% Critical Value
0	52	-1619.706	.	89.959	47.21
1	59	-1586.191	0.6979	**22.927***	29.68
2	64	-1575.827	0.3094	2.200	15.41
3	67	-1574.742	0.0380	0.030	3.76
4	68	-1574.727	0.0005		

Table 1.2: Johansen test for cointegration – Petroleum

Maximum Rank	Parameters	LL	Eigenvalue	Trace statistic	5% Critical Value
0	52	-2285.280	.	54.265	47.21
1	59	-2268.483	0.4511	**20.670***	29.68
2	64	-2262.279	0.1987	8.262	15.41
3	67	-2259.726	0.0871	3.156	3.76
4	68	-2258.148	0.0548		

Appendix E

Figure 1.1: Eigenvalue Stability Condition (Cigarettes)

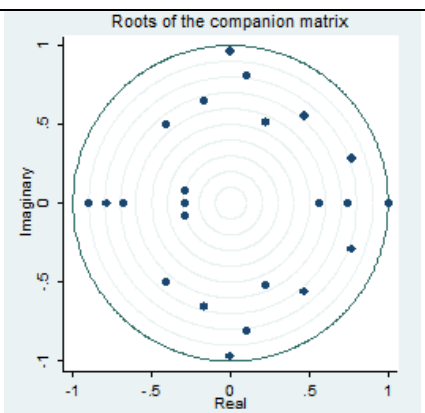
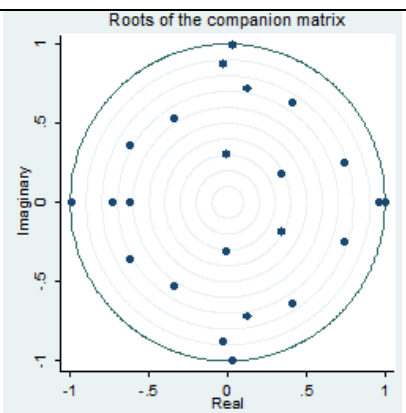


Figure 1.2: Eigenvalue Stability Condition (Petrol)



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