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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 (at the 10% significance level) as well as for electricity and motor fuel (at the 5% significance level).

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

[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.

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).

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 a 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.

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

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. 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 region 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 behaviors, 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

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

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 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%.

[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)

[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.

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 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 expanding 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 Røsdeth, 1983). In addition, it allows for weak seperability, hence allowing for multistage budgeting[9].

[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).

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 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:

$$\ln(P_t) = \sum_{j} w_{(r)t} \ln\left(p_{(r)t}\right) \tag{2}$$

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

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

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 *r*th commodity group. As above, we use Stone's (geometric) price index:

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

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:

[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.

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

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:

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

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

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

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

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

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:

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

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

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*.

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

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:

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

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

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

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

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 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):

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

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

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 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

[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

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 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 tobacco, 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 3: 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[15] repeated random

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

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.

Table 4a: 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 4b: 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. While this does not mean that taxation is not a suitable policy alternative, it does imply that legislation is not significant in reinforcing the effects from taxation to change consumer information. 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 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**	**Total own-price**	**Total 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