

CERE Working Paper, 2013:3

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

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

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27<sup>th</sup> September, 2013

## 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 signaling 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 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).

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

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

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<sup>1</sup> This paper is written in connection with:  
CERE (Centre for Environmental and Resource Economics)  
Graduate School in Population Dynamics and Public Policy

# 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 a producer price change, this is referred to as the *signaling effect* from taxation. The existence of the signaling 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 regulations 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 behavior 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. However, this simple framework, that the consumer is affected only through the budget restriction, is the focus of attention in this article.

Behavioral economists have supplied arguments questioning the simple mechanism from basic consumer theory into what has been denoted 'signaling 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 signaling 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 signaling effect through the models we estimate.

For example, a carbon tax may make the car driver aware of the pollution problem, and hence changes the behavior 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 signaling 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 signaling 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.

The main contribution of this paper is that we test for this kind of signaling effect for different countries and various goods with interactions from legislation (i.e. restrictions, advertising, etc.). Such changes in the signaling effect are analyzed specific to an individual country as to give the specific effect for that country<sup>2</sup>. 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 signaling effect on harmful commodities. The purpose of this article is to present an analysis on the significance of the signaling effect not to test why the signaling effect may be significant for one commodity but not for another.

Another interpretation this article makes is the difference between the signaling 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 externalities (tobacco and alcohol) which are also known as negative internalities. 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.

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<sup>2</sup> As described in Chapter 3.1, the countries we provide specific analysis for are Sweden, Denmark and the United Kingdom.

## 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 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<sup>3</sup> 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 signaling effect within tobacco taxation in the EU, and specifically how taxes as a signal may change the fundamental behavior 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 large incidences of drunken driving, disorderly conduct and alcohol-related violence (WHO, 2002). In a review by Wagenaar *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). However, it 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.) 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 signaling information to the consumer remains untested. As for tobacco, there seems to be no robust analyses on the effects of alcohol taxation having signaling 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 behavior 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 kilometers 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).

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<sup>3</sup> Such shocking measures are images of rotten lungs, decaying teeth, a baby with an oxygen mask and a man with a cancerous tumor on his throat.

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 ‘addiction’ as it is technically difficult to find substitutes. This is to some extent revealed through demand being relatively inelastic,<sup>4</sup> 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 behavior’, 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 Truys (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 nonexistent, 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 1966 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 show 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 modeling 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<sup>5</sup>, considers Swedish environmental taxes using time series data<sup>6</sup> for different commodity groups<sup>7</sup> 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

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<sup>4</sup> 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 (Stern, 2006)

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

<sup>6</sup> Data includes taxation, household expenditure consumer price and producer price index levels

<sup>7</sup> Split into four main groups: “Foodstuff”, “Transport”, “Heating” and “Other goods”

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.

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 behavior. 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 1970-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 analyze 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 be 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 public good nature of the good, I 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 behavior, 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 Modeling 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 separability, 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:

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

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  $p_j = \bar{p}_j + tax_j$ . We may then define the implicit tax on commodity  $j$  as:

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

which enables us to express the consumer price as:

$$p_j = \bar{p}_j(1 + \tau_j) \quad (2)$$

Substituting this into equation (1) gives us then:

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

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

If we then allow for different parameters representing the producer price and taxation, we may then rewrite the equation system to be estimated as:

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

Our central interest in this study is the magnitude of  $\gamma_{ij}$  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 behavior.



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):

$$w = \alpha + \gamma \ln(\bar{p}(1 + \tau)) + (\tilde{\gamma} - \gamma) \ln(1 + \tau) + \beta \ln(x/P) + \varepsilon \quad (5)$$

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:

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

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  $t$ ,  $\bar{p}_{(r)t}$  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:

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

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  $r$ ,  $\bar{p}_{i(r)t}$  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  $r$ th 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:

$$\ln(P) = \sum_j w_j \ln(p_j)$$

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. I denote the advertising and legislative effects as an array of  $m$  dummy variables denoted by  $L$  with coefficient  $\mu$  which takes the value of 0 at 1970 and then 1 for each major advertising/legislative change<sup>8</sup>. 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:

$$\mu_2 \mathbf{L}_2 = (0 \quad \mu_1 \quad \mu_2) \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{pmatrix} \quad (8)$$

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 assumed that the coefficient,  $\mu$ , 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  $\psi_m$  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:

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

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

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

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:

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<sup>8</sup> Details on the determination of these values will come in section 2.2 and illustrated in Appendix A

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

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 analyzed 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:

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

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:

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

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 ( $1 + e_{i(r)}$ ). Finally the third factor measures the effect of the change in within group expenditure has on the consumption of the  $i$ th good ( $E_{i(r)}$ ).

### 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<sup>9</sup>. 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 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 analyze 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", "Electricity". "Household appliances" constitute the "Furnishings

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<sup>9</sup> Statistiska Centralbyrån (SCB) in Sweden, Danmarks Statistik in Denmark and the Office of National Statistics in the United Kingdom

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 <sup>10</sup> 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 analyze 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 analyzed 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 analyzed 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.

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

<b>Commodity Group</b>	<b>Budget Share</b>	<b>Individual Commodity</b>	<b>Budget Share</b>		
Foodstuff	0.2137	Tobacco	(i): 0.0194 (ii): 0.0910		
		Alcoholic beverages	(i): 0.0311 (ii): 0.1438		
		<i>Spirits and wine</i>	(i): 0.0223 (ii): 0.1020		
		<i>Beer</i>	(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
				<i>Electricity</i>	(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	(i): 0.0436		

<sup>10</sup> Taken as the average value of budget shares from 1970-2008

		household goods	(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
		<i>Spirits and wine</i>	(i): 0.0144
			(ii): 0.0714
		<i>Beer</i>	(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
		<i>Electricity</i>	(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<sup>16</sup>:**

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
		<i>Spirits and wine</i>	(i): 0.0135
			(ii): 0.0767

		<i>Beer</i>	(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
		<i>Electricity</i>	(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<sup>11</sup> 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

<sup>11</sup> The term ‘major’ is given based on the discretion of the author given the impact of the legislation.

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<sup>12</sup>.

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 labeled 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.

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.

### *3.1 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 behavior. 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.

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<sup>12</sup> 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

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 piece of legislation introductions mainly refer 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 labeling 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<sub>2</sub> 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 labeling of appliance 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 labeling 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 labeling. 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 1997, this refers to introduction of labeling 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 labeling on motor vehicles describing the amount of CO<sub>2</sub> emissions per km travelled. For the legislation introduction in 1999 this refers to advice to households on how to minimize fuel consumption and the impact of CO<sub>2</sub> 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 labeling 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 behavior. However, for “Spirits and Wine”, we see a significant positive interaction effect for Int. Term 3 regarding alcoholic allergenic effects labeling.

Regarding legislation on petrol, we find significantly 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 labeling 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.

### *3.2 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.

### *3.3 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<sup>13</sup> 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).

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

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:

<b>Main Commodity Groups</b>	<b>Own-price</b>	<b>Expenditure</b>
Foodstuff Price	-0.751	0.664
Foodstuff Tax	<b>-1.046***</b>	
Household Energy and Utilities Price	-0.665	0.678
Household Energy and Utilities Tax	<b>-0.940***</b>	
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:

<b>Commodity</b>	<b>Own-price</b>	<b>Expenditure</b>	<b>Total own-price</b>	<b>Total Expenditure</b>
<i>Foodstuff</i>				
Tobacco Price	-1.027	0.532	-1.029	0.443
Tobacco Tax	-0.281		-0.280	
Alcoholic Beverages Price	-0.883	0.664	-0.877	0.225
Alcoholic Beverages Tax	-1.166		-1.167	
Spirits and Wine Price	-1.637	0.713	-1.633	0.470
Spirits and Wine Tax	-1.996		-1.997	
Beer Price	0.251	0.215	0.251	0.029
Beer Tax	-2.102		-2.103	
Meat Price	-0.445	0.945	-0.438	0.564
Dairy Products Price	0.037	1.098	0.044	0.016
Fish and Seafood Price	-0.320	0.555	-1.478	0.805
Non-Alcoholic Beverages Price	0.114	1.014	-0.175	0.065
<i>Household Energy and Utilities</i>				
Electricity Price	-1.300	0.981	-1.290	0.812
Electricity Tax	<b>-1.946**</b>		-1.933	
Electricity and Gas Price	-0.333	1.013	-0.323	0.801
Electricity and Gas Tax	2.104		2.117	
Petrol Price	-0.238	0.585	-0.230	0.388
Petrol Tax	-0.150		-0.141	

<i>Other Commodity Groups</i>				
Household Appliances Price	-2.504	1.670	-2.502	2.676
Clothing and Footwear Price	-1.384	0.921	-1.357	0.561

\*\*\*, \*\*, \*: 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<sup>14</sup>. 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 for commodities 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:

<b>Main Commodity Groups</b>	<b>Own-price</b>	<b>Expenditure</b>
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

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

<b>Commodity</b>	<b>Own-price</b>	<b>Expenditure</b>	<b>Total own-price</b>	<b>Total Expenditure</b>
<i>Foodstuff</i>				
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	-0.269	-0.313	-0.270	-0.192

<sup>14</sup> This contradicts findings made by Ghalwash (2007) where transportation has the opposite result.

## Price

<i>Household Energy and Utilities</i>				
Electricity Price	-0.243	0.565	-0.243	0.286
Electricity Tax	<b>-1.896***</b>		-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	
<i>Other Commodity Groups</i>				
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:

<b>Main Commodity Groups</b>	<b>Own-price</b>	<b>Expenditure</b>
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:

<b>Commodity</b>	<b>Own-price</b>	<b>Expenditure</b>	<b>Total own-price</b>	<b>Total Expenditure</b>
<i>Foodstuff</i>				
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
<hr/>				
<i>Household Energy and Utilities</i>				
Electricity Price	0.073	0.262	0.075	0.192
Electricity Tax	<b>-1.056***</b>		-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	<b>-1.346**</b>		-1.343	
<hr/>				
<i>Other Commodity Groups</i>				
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 stark 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 signaling 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 signaling negative public effects for consumption of electricity in all three countries and petrol in the UK. However, taxation seems less effective in signaling 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 signaling 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 signaling 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 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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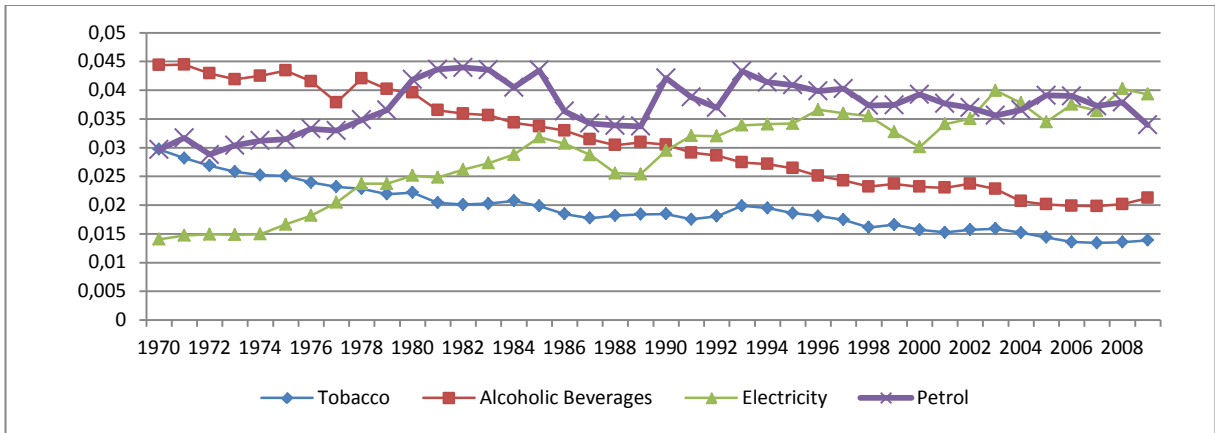
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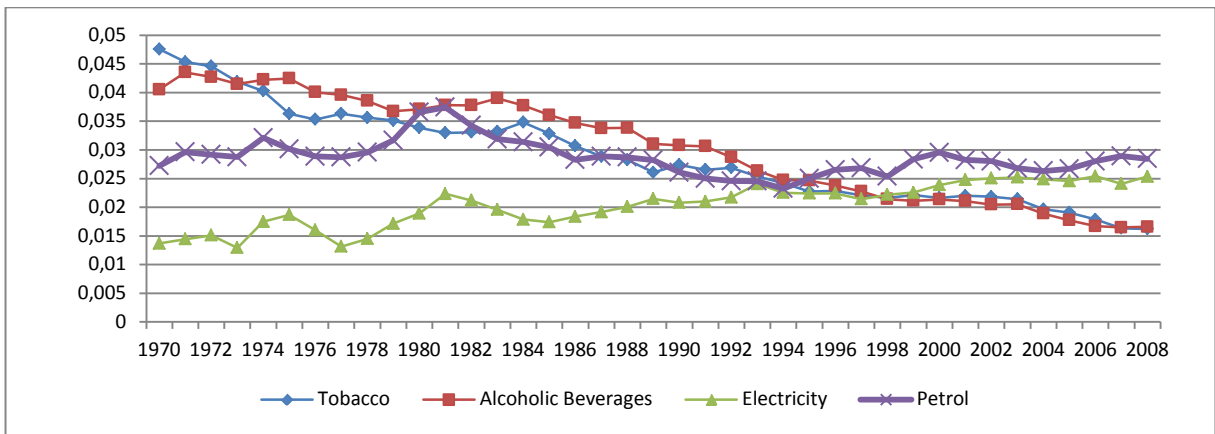


# Appendix A

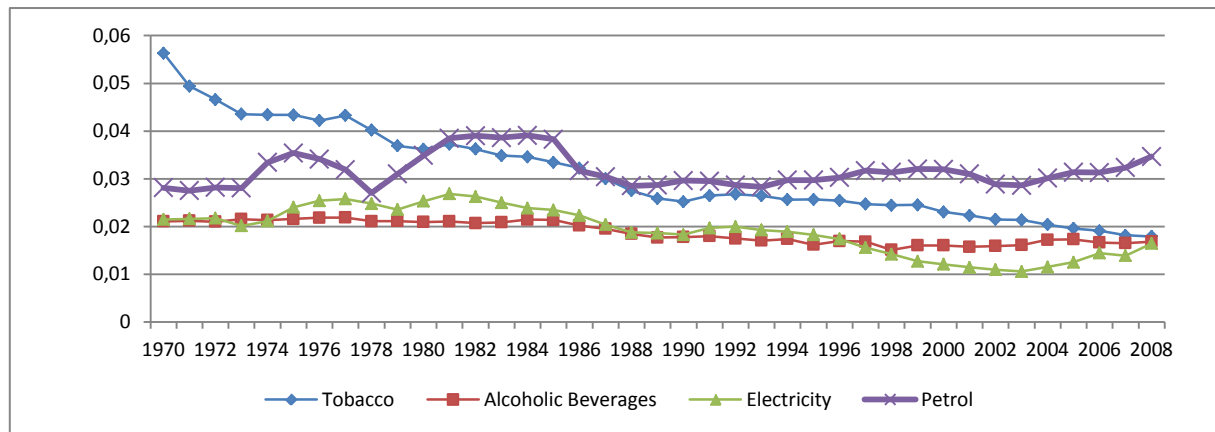
**Figure 1:** Household budget shares, Sweden



**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 labeled (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](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](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)

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UK Parliament Legislation Archive - <http://www.legislation.gov.uk/>  
 EU Directives: [http://ec.europa.eu/health/tobacco/law/index\\_en.htm](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).

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EU Directives: [http://europa.eu/legislation\\_summaries/consumers/index\\_en.htm](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)

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EU Directives: [http://europa.eu/legislation\\_summaries/consumers/index\\_en.htm](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)

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EU Directives: [http://europa.eu/legislation\\_summaries/consumers/index\\_en.htm](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 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	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	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)

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	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)
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 color 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 color 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 color 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:

	<b>Foodstuff</b>	<b>Household Energy and Utilities</b>	<b>Furnishings and Household Goods</b>	<b>Apparel, Textiles and Maintenance</b>
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:

	<b>Tobacco</b>	<b>Alcoholic Beverages</b>	<b>Spirits and Wine</b>	<b>Beer</b>
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	0.0016 (1.06)	0.0036 (2.36)	0.0019 (2.22)	0.0003 (0.90)
Int. Term 1	0.0111 (1.39)	(omitted)	(omitted)	(omitted)
Legislation 2	0.0013 (0.51)	-0.0041 (-0.96)	-0.0027 (-0.86)	0.0007 (0.77)
Int. Term 2	0.0205 (1.10)	-0.0069 (-0.41)	0.0232 (1.56)	0.0074 (1.22)
Legislation 3	-0.0063 (-5.36)	0.0067 (1.85)	0.0044 (1.44)	-0.0016 (-1.21)
Int. Term 3	-0.0278 (-6.32)	0.0424 (1.46)	0.0233 (1.56)	-0.0524 (-2.57)
Legislation 4	-0.0088 (-0.67)	-0.0918 (-1.15)	-0.0073 (-0.39)	0.0156 (3.90)
Int. Term 4	-0.0273 (-0.67)	-0.3041 (-1.16)	-0.0180 (-0.44)	0.1136 (3.97)
Legislation 5	0.0175 (1.07)	0.0947 (1.13)	0.0165 (0.55)	-0.0082 (-2.95)
Int. Term 5	0.0530 (1.14)	0.3087 (1.15)	0.0372 (0.58)	-0.0624 (-3.21)
Legislation 6	0.0006 (0.59)	-0.0095 (-1.36)	-0.0188 (-1.20)	-0.0024 (-0.78)
Int. Term 6	(omitted)	-0.0289 (-1.35)	-0.0429 (-1.25)	-0.0117 (-0.95)
Legislation 7	0.0009 (1.39)			
Int. Term 7	(omitted)			

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

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

	<b>Meat</b>	<b>Dairy Products</b>	<b>Fish and Seafood</b>	<b>Non-Alcoholic Beverages</b>
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:

	<b>Electricity</b>	<b>Electricity and Gas</b>	<b>Petrol</b>
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:

	<b>Household Appliances</b>	<b>Clothing and Footwear</b>
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:

	<b>Foodstuff</b>	<b>Household Energy and Utilities</b>	<b>Furnishings and Household Goods</b>	<b>Apparel, Textiles and Maintenance</b>
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	0.0363 (1.38)	0.0782 (2.62)	-0.0328 (-1.99)	0.0526 (1.86)



Goods Price				
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:

	<b>Tobacco</b>	<b>Alcoholic Beverages</b>	<b>Spirits and Wine</b>	<b>Beer</b>
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 Int. Term 1	-0.0100 (-2.26)	-0.0013 (-0.60)	0.0037 (2.07)	-0.0024 (-2.54)
	-0.0578 (-1.49)	0.0107 (0.99)	0.0275 (2.57)	-0.0053 (-0.84)
Legislation 2 Int. Term 2	0.0014 (0.16)	0.0204 (0.85)	-0.0161 (-0.99)	0.0164 (3.27)
	0.0182 (0.34)	0.0673 (0.97)	-0.0356 (-0.92)	0.0527 (3.60)
Legislation 3 Int. Term 3	0.0095 (2.14)	-0.0159 (-0.70)	0.0068 (0.41)	-0.0102 (-2.62)
	0.0556 (2.48)	-0.0433 (-0.68)	0.0148 (0.38)	-0.0284 (-2.59)
Legislation 4 Int. Term 4	-0.0032 (-0.42)			
	-0.0113 (-0.68)			
Legislation 5 Int. Term 5	0.0004 (0.57)			
	(omitted)			
Legislation 6 Int. Term 6	-0.0371 (-1.14)			
	-0.0733 (-1.08)			
Legislation 7 Int. Term 7	0.0329 (0.86)			
	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:

	<b>Meat</b>	<b>Dairy Products</b>	<b>Fish and Seafood</b>	<b>Non-Alcoholic Beverages</b>
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:

	<b>Electricity</b>	<b>Electricity and Gas</b>	<b>Petrol</b>
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	0.0024	-0.0068

	(0.31)	(0.67)	(-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:

	<b>Tobacco</b>	<b>Alcoholic Beverages</b>	<b>Spirits and Wine</b>	<b>Beer</b>
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 Int. Term 1	-0.0165 (-1.32)	-0.0008 (-1.85)	-0.0002 (-0.33)	0.0001 (0.32)
Legislation 2 Int. Term 2	-0.0693 (-1.18)	(omitted)	-0.0015 (-0.39)	-0.0007 (-1.01)
Legislation 3 Int. Term 3	-0.0175 (-2.01)	5.24e-06 (0.00)	-0.0010 (-1.51)	-0.0004 (-1.59)
Legislation 4 Int. Term 4	0.0367 (1.93)	-0.0038 (-1.52)	(omitted)	(omitted)
Legislation 5 Int. Term 5	0.0361 (2.04)	-0.0248 (-1.29)	-0.0087 (-2.28)	0.0425 (1.64)
Legislation 6 Int. Term 6	-0.0593 (-2.06)	0.0341 (1.29)	0.0229 (2.31)	-0.0447 (-1.64)
Legislation 7 Int. Term 7	-0.0202 (-2.08)	0.0405 (1.48)	0.0127 (1.31)	-0.0405 (-1.56)
Legislation 8 Int. Term 8	0.0254 (1.92)	-0.0497 (-1.41)	-0.0238 (-1.27)	0.0424 (1.57)
Legislation 9 Int. Term 9	(omitted)			
	-0.0008 (-0.70)			
	0.2487 (0.38)			
	-0.1879 (-0.38)			
	-0.2419 (-0.37)			
	0.1826 (0.37)			
	(omitted)			
	0.0007 (1.24)			
	(omitted)			
	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:

	<b>Meat</b>	<b>Dairy Products</b>	<b>Fish and Seafood</b>	<b>Non-Alcoholic Beverages</b>
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:

	<b>Electricity</b>	<b>Electricity and Gas</b>	<b>Petrol</b>
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: $\gamma_{ij} \geq \bar{\gamma}_{ij}$	Null Hypothesis: $\gamma_{ij} \leq \bar{\gamma}_{ij}$
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: $\gamma_{ij} \geq \bar{\gamma}_{ij}$	Null Hypothesis: $\gamma_{ij} \leq \bar{\gamma}_{ij}$
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:

<b>Commodity</b>	<b>F-test</b>	<b>Null Hypothesis: <math>\gamma_{ij} \geq \bar{\gamma}_{ij}</math></b>	<b>Null Hypothesis: <math>\gamma_{ij} \leq \bar{\gamma}_{ij}</math></b>
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