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

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

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

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

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# 1. Introduction

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

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

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

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

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

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

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

# 2. Background and hypotheses

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

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

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

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

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

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

The main aim of industrial communication is to incentivize the public to ignore or reject state research and signals through various motivations. This is especially the case if the state's communication is uncomfortable to believe, i.e. if there is skepticism as to the severity of the negative effects from consumption. As stated by Warner (1985) the tobacco industry's media response has three key tactics: (1) Focus is given on the non-health attributes of smoking, such as flavor, satisfaction, sex appeal, and individuality; (2) Given the mass amount of scientific evidence against smoking, the tobacco industry uses these concerns to promote "less-hazardous products" to lower the concern and stigma to the public. Furthermore, as stated by Brownell and Warner (2009), to counter research on the harmful effects of tobacco, the tobacco industry is keen on labeling this research as 'junk science', and denying the addictive and destructive nature of smoking; (3) Lastly, the largest goal is to maintain or increase market expansion amongst new consumers and for those considering quitting. Due to the highly addictive nature of tobacco, it is vital that the industry gains new long-term customers in the face of government advertisements encouraging others to quit smoking.

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

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

Finally, the other major industry responses considered in this article is the role of lobbying[8]. Where media expenditures are considered direct communication, lobbying may be considered to be an indirect form of communication seeking to persuade policymakers on what is good public policy. Specifically this includes influencing statements made by politicians and decisions on policy. The public is also made aware of these messages, through rules directing extensive disclosure, legislative decisions, and through politicians' statements and decisions[9]. This subject fits in with the field of political equilibrium theory and characteristics of basic signaling models in game theory (Brock and Magee, 1978; Kollman, 1998). This forms a traditional rent seeking view

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

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

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

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

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

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

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

explanatory variables including a time trend, quarterly dummy variables, California's state tax, the federal tax rate, retail price (minus state tax) as well as state and industrial media variables.

From Hu *et al.* (1995a), results show that the state media campaign has a statistically significant negative effect on cigarette consumption and the industry media campaign has a statistically significant positive effect on consumption. Other effects show that the state tax rate on cigarettes, the federal tax rate and time trend show statistically significant and negative impacts on cigarette consumption. This study departs from Hu *et al.* (1995a), and expands upon it as it examines the effects of taxation and state media campaigns along with the industrial counterbalancing response. A further key feature that this article will use an alternative methodological procedure to achieve these aims.

Another contribution that this study provides is that we expand upon previous empirical studies which have focused mainly on media advertising as the central form of communication without consideration for more implicit communication in the political field through lobbying. Hu *et al.* (1995b) alluded to the effects of lobbying by quoting Begay *et al.* (1993) that for California, lobbying efforts may have been cost-effective for the tobacco industry compared to countering the state's media campaign. This provides a potentially valuable research area to explore. Through much discussion on the importance and effectiveness of lobbying, lobbying is said to have a sporadic or unknown effect where, "*sometimes these campaigns have their effects – just as rain sometimes follows the rainmakers' dance*" (Kollman, 1998). However as Kollman (1998) states, most of the conclusions of the influence of contributions may have something to do with the lack of research on this topic which shows the importance of such a study in this article. While this article does not aim to explore why the patterns of lobbying have changed over the years, reasons behind this trend are unclear.

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

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

# 3. Methodology

This section details the model and provides a description of the data used in the empirical analysis. The underlying framework for the econometric model is that consumers base their consumption decision on their preferences for goods and their budget constraint, given the information they have on the characteristics of the goods. This means we may model consumer demand as a function of prices, income and consumers' knowledge about the characteristics of the good. Paramount to this study is that we allow consumers' perception about the characteristics of the good to be affected directly by information campaigns by the state,

marketing campaigns by the industry and indirectly through industry lobbying as discussed above. To accomplish this, this paper employs a Vector Error Correction Model (VECM) approach as originally employed by Davidson *et al.* (1978), Hendry and von Ungern-Sternberg (1981), and Salmon (1982). The advantage of using a VECM model, as opposed to a standard Error Correction Model (ECM) is that there is less uncertainty of directional causality between variables. This is especially the case where there are more than two variables under consideration.

## *3.1 Modeling approach*

Not many topics in economics are longer or deeper than the literature on the household's decision to consume or save their available income. We know that prices are a key part of influencing consumption as the price effect directly impacts the budget constraint where typically we would expect that an increase in price would lead to a fall in consumption. These consumer prices consist of the producer price from the industry and taxes added by the state. Income is another key factor affecting consumption. As a consumer's budget constraint would rise, due to an increase in disposable income, the consumer is able to consume more. This is especially the case for luxury items which may impact consumption of other substitute items.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## *3.2 Description of the Data*

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

Consumption for tobacco is calculated as cigarettes consumed per capita whilst petroleum products are consumed per barrel (thousands) consumed per capita, respectively. These values are taken per capita to account for changes in the population. Population data is given by the United States Census Bureau. Quarterly values for cigarette consumption (per unit) are taken from the Alcohol and Tobacco Tax and Trade Bureau in the Department of the Treasury. We count cigarettes only as data on other forms of tobacco is not readily available for the timeline to the author's knowledge. As other forms of tobacco (chewing tobacco, snuff, etc.) form a small fraction of the total tobacco consumption, this should not lead to any estimation errors.

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

Petroleum consumption (in thousand barrels per day) refers specifically to distillate fuel oil and liquefied petroleum gases. Quarterly consumption data for this is given by the US Energy Information Administration (EIA). From Appendix B in Tables 1.1 and 1.2 for tobacco and petroleum, respectively, we see that consumption of cigarettes has steadily decreased over time at almost a constant rate. For petroleum, following an increase in consumption from 1998-2000, we see a steady decline in consumption on average.

Quarterly data for price is given by the producer price for cigarettes and petroleum excluding federal taxes in current prices. This producer price data is given as indices taken at the national or federal level where producer prices do not vary state by state. This is the most convenient method given availability of the data. This data is obtained from the United States Department of Labor Bureau of Labor Statistics (BLS). We see in Table 2.1 (Appendix B) for tobacco that producer prices seem to have steady climbed over time. For petroleum, in Table 2.2, producer prices have risen at a greater level over time apart from a drop in prices in 2009. Tobacco excise tax, measured in cents per pack of 20 cigarettes, is obtained quarterly from the average across all fifty states. This data is obtained from the Department of Health and Human Services Centers for Disease Control and Prevention (CDC). Likewise, the same principle is done for excise tax on petroleum products where quarterly data is obtained as an average across all states but measured in cents per gallon. This data is obtained from the U.S. Department of Transportation Federal Highway Administration (FHWA). We see in Table 3.1 (Appendix B) for tobacco that taxes rose at a gradual rate from 1998 to 2001 but rose quicker from 2002 to 2010 before slowing down again after. For petroleum, in Table 3.2, we see a steady increase in taxes over time on average, but less of an increase over time than for tobacco.

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

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

As mentioned for state ad spending concerning petroleum[11], the nature of advertising spending is not as it is with tobacco. Instead, we use data provided for the U.S. Global Climate Change Research Program (USGCRP) on research and transmission of results through various outlets as a measure of the state response. Data for the USGCRP is provided by the U.S. Global Climate Change Research Program[12] where financial reports are released annually. The USGCRP was established as described in the Global Change Research Act of 1990. Through thirteen agencies in the government, the USCGRP conducts research and trends on the level of climate change

[11] See Section 2

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

from energy use while providing suggestions on how to mitigate these problems. The final goal of the USGCRP is to communicate and educate to broaden public understanding of climate change through: (1) strengthening communication and education research; (2) reach diverse audiences; (3) increase engagement by the public; and (4) cultivate the scientific workforce. From Appendix B, Table 4.2, we see that state expenditures on media show, as for tobacco, a very irregular pattern. However, on average we see that there is a decrease in expenditures over time.

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

Comprehensive and consistent quarterly data on petroleum industry media expenditures is, however, particularly difficult to obtain and not readily available. Thus, a measure for media expenditures is done via proxy as explained. As suggested by the Union for Concerned Scientists, on average the petroleum industry spends 8% of its total profits on advertising and marketing. Using this benchmark, may not be a fully accurate representation of advertising spending but holds as an approximate figure for this study. Data on profits is given annually by the IEA (International Energy Agency). Using a sensitivity analysis, by altering marginally the percentages spent on petroleum industry advertising by 2% in either direction, it is found that these changes do not alter the significance of our results for our main variables of interest. Thus we can say that this benchmark for petroleum industry advertising may be an appropriate proxy. We see from Table 5.2 in Appendix B that industry media expenditures on petroleum have on average increased sharply from 1998 to 2007. Since 2008, following a political regime change, expenditures dropped sharply from 2008 to 2009 before increasing sharply again in 2010. However, since 2011 expenditures have dropped once more to levels less than what was seen in 2004.

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

However, for petroleum industry lobbying (Table 6.2), expenditures have grown quite dramatically from $15.8 million in 1998 (first quarter) to $36.5 million in 2012 (fourth quarter) with a long history of strong influence in Washington. Before, 2008, petroleum lobbying has remained fairly constant. It is argued that from the start of the presidency of George W. Bush in

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

# 4. Results

This section details the results from estimation of our empirical model described in Section 3. The key point of this analysis is to estimate the effects of state vs. industry responses on quarterly per capita consumption. To determine whether we may proceed with the Vector Error Correction Model (VECM) approach, we first conduct a stationarity test as detailed in the Methodology section through the Augmented Dicky-Fuller (ADF) test. Results from the ADF test for cigarettes and petroleum are presented in Appendix C, Table 1:

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

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

Next, we conduct cointegration tests, as described in Section 3 (though the Johansen test for cointegration). Results are shown in Appendix D for cigarettes (Table 1.1) and petroleum (Table

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

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

**Table 1:** Vector Error Correction Model - Cigarettes

Cointegrating equations:

| **Equation** | **Parameters** | **Chi2** | **P > chi2** |
|---|---|---|---|
| _ce1 | 7 | 1910.305 | 0.0000 |

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

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

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

expenditure is of the expected sign where a 1% increase in lobbying expenditure is likely to be followed by an increase in consumption by 0.184%.

**Table 2:** Vector Error Correction Model - Petroleum

Cointegrating equations:

| Equation | Parameters | Chi2 | P > chi2 |
|---|---|---|---|
| _ce1 | 6 | 392.2281 | 0.0000 |

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

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

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

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

# 5. Conclusion

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

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

For government media campaigns on petroleum, however, we do find significant results in the expected negative direction on consumption. Furthermore this elasticity value (-0.523%) is highest among the variables considered which implies that this form of communication has been successful in communicating messages to the consumer. This would indicate that the research campaign, the USGCRP, has been a valuable policy tool in communicating the effects of overconsumption of petroleum on the environment. This would be an encouraging sign that the public does seem to react to messages of climate change and pollution, which has been a course of great debate regarding the relevancy of the USGCRP. Hence, a policy recommendation would be an extension of funding into the program and an expansion of the program across the country.

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

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

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

Petroleum industry lobbying also holds a statistically significant positive effect on consumption whereby with campaigning through the government, these messages seem to resonate with the public. This furthermore confirms literature that petroleum lobbying has positive effects on consumption (see, e.g., Kolk and Levy, 2001; Gelbspan, 2004; Kolk and Pinkse, 2007). This appears to be a discouraging result where, despite increased goals by the current Obama administration to reduce greenhouse gas emissions by 17% by 2020[13], progress has been quite slow. Climate change denialism still appears to be a rampant problem in the U.S. Congress[14], where 161 elected officials from the 113th Congress (Jan-June 2013) have taken in over $54 million from the fossil fuel industry to vote against 'green policies' despite an overwhelming scientific consensus on the environmental and financial impacts of climate change[15] (Germain *et al.*, 2013; Spross, 2013). Furthermore, so-called 'attacks on the petroleum and oil industries' have been referred to as hurting U.S. jobs and against free market principles. This also may have had an impact over time on the effectiveness of state media campaigns to educate and inform the public where a growing proportion of the voting public also see media coverage as being exaggerated (Dunlap and McCright, 2008). These implications stress the importance of maintaining the stock of information to the public on the effects of climate change through media spending and the need to counter petroleum industry lobbying. Alternatively, the government may consider stricter legislation (e.g. spending limits) on lobbyists to curb influence.

[13] World Resources Institute, http://www.wri.org/project/us-climate-action

[14] Especially among the Republican Party where 90% of Republicans in the U.S. Congress deny climate change

[15] The United States in 2012 suffered $199 billion in economic losses due to extreme weather.

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# Appendix A

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

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

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

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

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

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

Similarly for the second variable, a similar relationship holds:

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

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

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

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

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

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

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

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

# Appendix B

**Figure 1.1: Tobacco Consumption (Cigarettes per capita)**

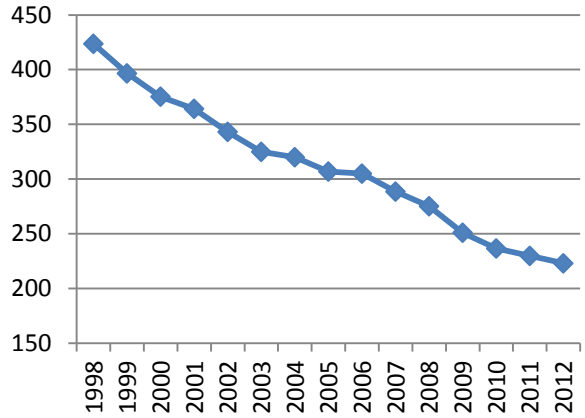



**Figure 1.2: Motor Fuel Consumption (Thousands of barrels per capita)**

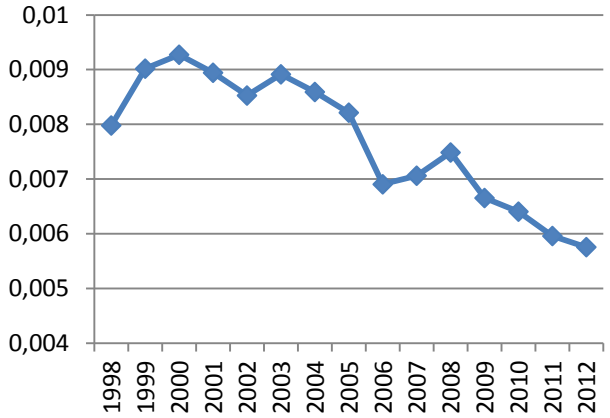



**Figure 2.1: Tobacco Prices**

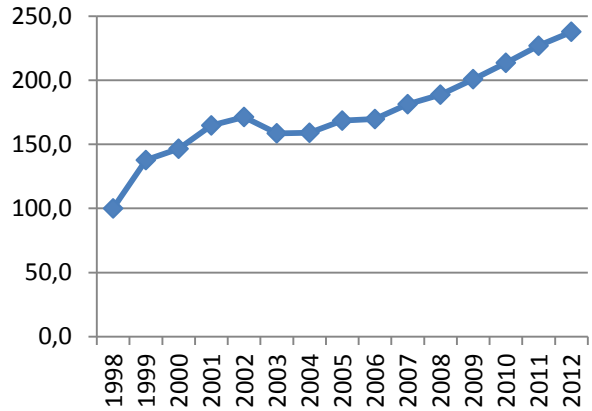



**Figure 1.2: Motor Fuel Prices**

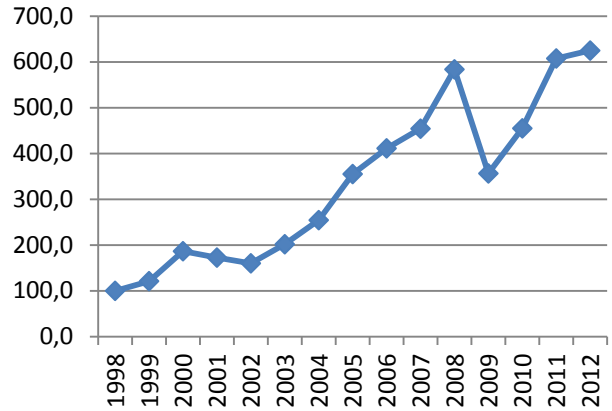



**Figure 3.1: Tobacco Taxes**

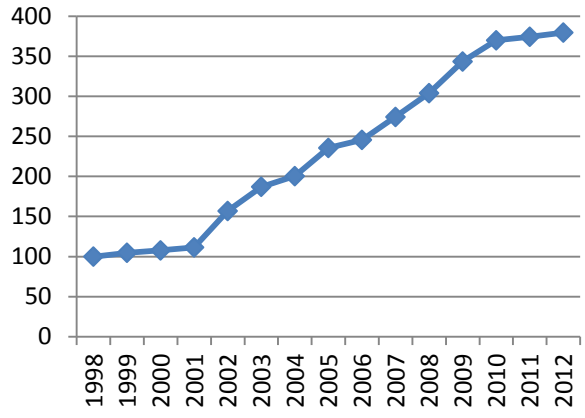



**Figure 3.2: Motor Fuel Taxes**

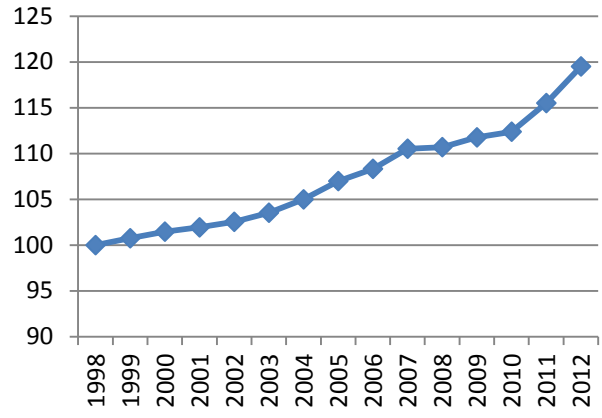


**Figure 4.1: State Tobacco Media Expenditures (US$)**

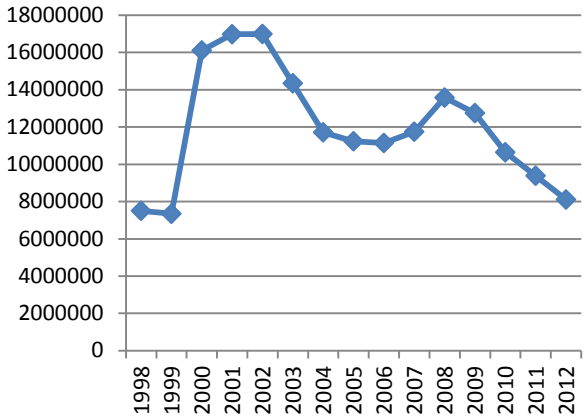



**Figure 4.2: State Petroleum Media Expenditures (US$)**

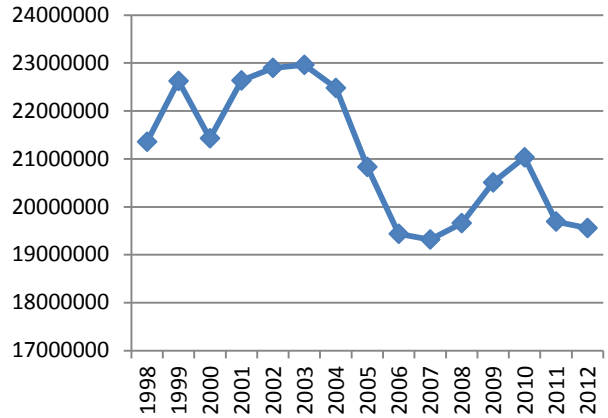



**Figure 5.1: Tobacco Industry Media Expenditures (US$)**

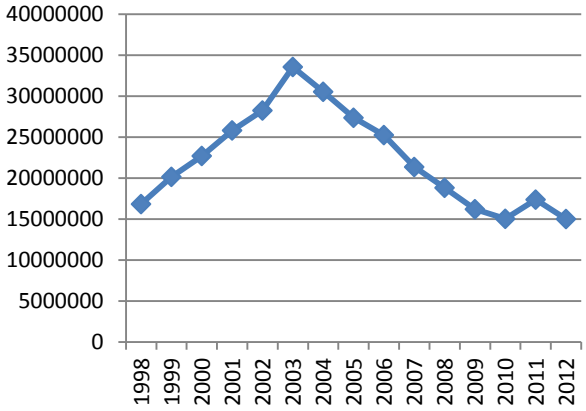



**Figure 5.2: Petroleum Industry Media Expenditures (US$)**

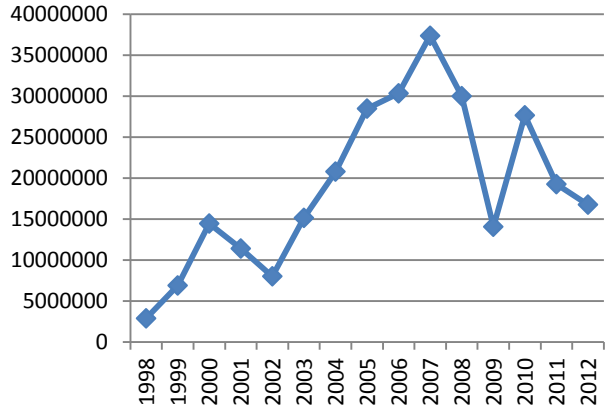



**Figure 6.1: Tobacco Industry Lobbying (US$)**

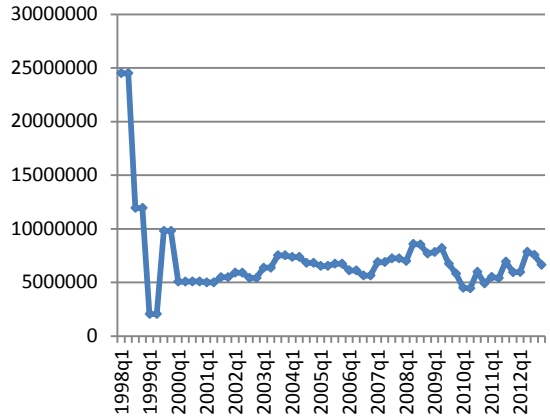
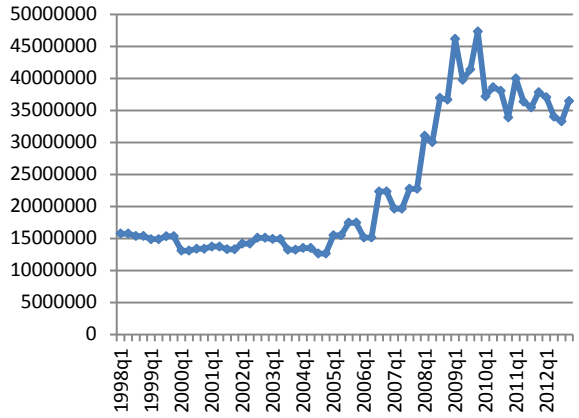



**Figure 6.2: Petroleum Industry Lobbying (US$)**



# Appendix C

**Table 1:** Augmented Dickey-Fuller unit root tests:

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

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

**Table 2.1:** Selection order criteria - Cigarettes

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

**Table 2.2:** Selection Order Criteria – Petroleum

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

# Appendix D

**Table 1.1:** Johansen test for cointegration – Cigarettes

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

**Table 1.2:** Johansen test for cointegration – Petroleum

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

# Appendix E

**Figure 1.1: Eigenvalue Stability Condition (Cigarettes)**

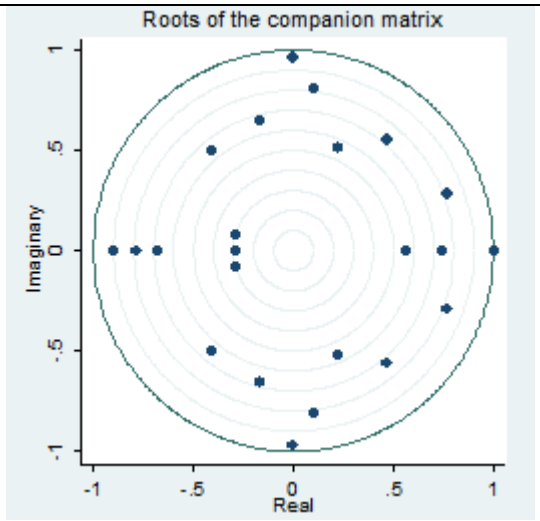



**Figure 1.2: Eigenvalue Stability Condition (Petrol)**