*Essay*

# Evaluating the evidence concerning the impact of cigarette taxes on smoking behaviour

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## Abstract

Smoking is a prominent issue within countries and has led to millions of premature deaths and expensive health complications, which harms the economy. This paper aims to examine the variables that impact cigarette consumption and whether cigarette taxation alone is enough to prevent people from smoking. The model was estimated by using the Ordinary Least Squares (OLS). The results discovered show a significant negative correlation between cigarette taxation and cigarette consumption. The findings are similar to a significant number of other literature pieces, demonstrating that further research is needed to find the optimal methods to reduce the consumption of cigarettes.

**Keywords:** Addiction, Smoking, Taxation, Economics

## Introduction

The significance of smoking as a contributor to preventable illness and premature death is now widely accepted and proactively addressed by governments globally. Annually, according to the Department of Health, smoking alone causes around 79,000 deaths in England, with a predicted cost to the National Health Service (NHS) of £2.5 Billion in 2015. Over the past decade, a broad range of government and health group interventions have been implemented and evaluated. These have been especially targeted at young people due to the perpetuation of smoking into adult life, which arises the issues of the long-term effects associated with health loss and medical costs. There is a broad range of literature surrounding this topic which explores





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many different aspects of the specifics that affect smoking behaviour and the most effective elements in reducing demand.

The primary purpose of this paper is to observe the effect of cigarette taxation on cigarette consumption within the United Kingdom (UK). Many of the studies within the literature have taken place in Asia or the United States of America; there have only been a small number of relevant papers that use up-to-date data within the UK. There is, therefore, a need for further analysis to evaluate the differences specifically within the UK market. This paper will evaluate the significance of increasing taxation on cigarette consumption and whether these results coincide with findings from other countries. A logical explanation of any differences that may exist will also be presented. The model was estimated using an OLS estimate to regress the cigarette consumption in the UK against multiple explanatory variables.

The results from the OLS regression show that as cigarette prices increase by 10%, the level of annual cigarette consumption per person decreases by 21.4%. This estimate supports the ideas of economic demand and supply theory, which is reflected in the other empirical evidence. Alongside this, other literature pieces reviewed in the research show that as price increases, demand decreases. The size of the estimate can be attributed to several economic theories; it is therefore directionally correct and consistent with the other literature pieces reviewed.

The main limitation of the empirical model is the possibility of heteroscedasticity, autocorrelation, and multicollinearity. However, it is commonly accepted that such problems arise in time-series data, and therefore several tests will be used to eliminate them as practicably as possible. The tests used to deal with these problems are the White Test, robust standard errors, Breusch-Watson test, and multicollinearity procedures.

The remainder of the paper will be organized as follows: Section 2 will discuss the other literature pieces; Section 3 describes the data sources and includes a thorough description of the variables and their relation to the model; Sections 4 and 5 provide an outline of the empirical model and evaluate the results; Section 6 discusses the limitations surrounding the project and what areas could be improved; and lastly, Section 7 summarises the key findings and recommendations.

## Literature Review

It is widely accepted amongst economic theorists that one of the quickest and most inexpensive



 
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routes to lower demand for a good that has negative externalities is to apply a tax to it, as opposed to passing a restrictive access law or a non-direct policy. A good with negative externality is a good that affects a third party indirectly through the transaction of the good. In the case of cigarettes, the third party (individuals and the environment) are negatively affected by consumers' smoking.

## The Effects of Smoking

Smoking affects everyone who is around the smoker, both emotionally and physically. Many people die prematurely due to smoking-related illnesses, which are preventable by not smoking, seen in Hu et al. (2002). People may also be affected by the sight of their loved ones suffering due to a smoking-related illness; this can also cause psychological problems later in life, which reduces their ability to work productively. This causes a loss of earnings to the individual and tax revenue to the economy as there would be a reduction in productivity and any loss of skills that the individual may have. The health services, particularly in the UK, are under immense levels of pressure because of the real term decrease in their health budget that the health service receives annually. In 2017 the Institute of Economic Affairs (IEA) discovered that the government spends £3.6 billion on smoking-related diseases per year. The individuals that need medical attention due to smoking are putting the NHS under more stress than before and possibly stopping other individuals from receiving important surgeries.

Deforestation is a significant problem as well, with many forests being cut down for manufacturers to grow more tobacco. In 2011 the World Health Organization (WHO) estimated that the area used to grow tobacco is approximately 4,200,00 hectares, which makes up about 1% of all land globally; however, this land could be used for essential goods instead. Additionally, the distribution of millions of cigarette packets across the world creates a lot of air pollution through transportation. Furthermore, the chemicals that are needed to grow tobacco are very harmful to the surrounding environment and often leak into the water system, which destroys ecosystems. This devastation is further perpetuated by the immense number of cigarette butts that are thrown onto the floor, according to Novotny (2015).

Second-hand smoking has historically been a significant cost to individuals and previously unrecordable. However, once this was discovered and deemed substantial, it led to a smoking ban



 
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in public places in 2007, as well as people not being able to smoke in the car with an individual who is under 18 years of age.

Governments have a difficult task as they need to weigh up the expenses involved in responding to the cost to the NHS and the loss of productivity of the economy. However, governments do take into consideration that the people who die prematurely from smoking-related illnesses do not draw from their pension or other governmental resources, thus reducing the government expenditure on pension. According to the IEA, it is estimated that the government saves £9.8 Billion a year from the premature deaths of smokers. Additionally, it is estimated that there is a net saving of £14.7 billion per year from premature smoking-related deaths. This data shows that it is in the government's best interest financially to maintain the current situation.

## Addictiveness of Smoking

One of the reasons why cigarettes are overly addictive is because of the nicotine that alters the chemical balance in individuals' brains. According to the NHS website, the chemical alterations in the brain change the smoker's mood and concentration levels. Additionally, the act of smoking regularly can become a habit that is very difficult to break. Therefore, many individuals are not addicted to smoking itself, but to the act of smoking and the social inclusion that it brings to their working lives.

Cigarettes are addictive, and therefore many academics believe that addictive goods do not strictly adhere to the laws of economic behaviour. However, Becker et al. (1988) state that people behave rationally by maximising their utility for the good as they would for a normal good. Despite this, some conditions need to be considered with addictive goods that make them differ from normal goods with significant external factors. The main external factors that Becker et al. (1988) mention are age and stressful events, which cause the demand for addictive goods to increase. It is noted that normal goods will not be as significantly affected by these factors. Historically, age has been found to influence individuals to consume more cigarettes in their younger years due to society and peer pressure. Conversely, in later years evidence has shown that people will consume more addictive goods as the negative aspect of dying early is not as relevant as before. However, it is worth noting that the older population has not had the benefit of education on the dangers of smoking to the same extent as the younger generation. Nevertheless, it is evident that stressful events lead individuals to crave addictive goods more to help deal with their problems.



 
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## How Different Consumers Are Affected

Unsurprisingly, price increases affect different socioeconomic groups differently. The groups affected most are younger people (<24 years old), low-income individuals (< $25,000 a year), and people with little educational qualifications (people who exit education prior to A-Levels or equivalent). Franz (2008) states that younger people are affected more by price change making them more price responsive than older people. This is also seen in Bader et al. (2011), though it is worth noting that the sample size used was very small. Franz (2008) states that older individuals are also significantly affected by price increases due to the reduction in income in later life. Wasserman et al. (1991) discovered that married people smoke less than un-married people, but this could be correlated and not causal. Harris and Chan (1999) uncover that as age increases from 18-29 the price elasticity dropped significantly from -0.831 to -0.095. This reduction shows that younger individuals are greatly affected by a change in cigarette prices compared to other age groups. Sharbaugh et al. (2018) contend that the lowest income individuals were affected the most, which is as expected due to individuals having such a low disposable income budget. This small amount of disposable income means that there will be a trade-off between other goods that are much more useful; this is similar to Chaloupka et al. (2002). Goodchild et al. (2016) created a simulation model to test how low, lower-middle, upper-middle, and high-country-income groups would react to a $1 increase in excise tax to all countries. The data found that the country in the low-income group reduced their annual consumption by 32%, which was significantly higher than all the other countries' income groups. This shows that the lower-income group is the most responsive to the price changes as they alter their annual consumption the greatest. However, this does not include any illegal purchases that take place, which would be especially prominent within countries with low-income groups; therefore, this large decrease in annual consumption may not be as large as it states. As expected Chaloupka et al. (2002) discovers that higher prices prevent relapse among past smokers. According to Becker et al. (1988); Chaloupka (1991), heavy abusers of addictive goods drastically change consumption according to the price. Wasserman et al. (1991) find that individuals with higher education consume fewer cigarettes than someone with a lower education; this is also seen in Bader et al. (2011); Chaloupka et al. (2002).

Lee et al. (2005) look at the significance of the 5 New Taiwan Dollar tax increase on domestic and imported goods, cigarettes, and cigars. This tax increase works out as approximately a 20% increase in price. Before the tax increase, only 7-10 minutes of work was required to earn enough



 
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to buy a pack of cigarettes. Lee et al. (2005) use a demand model that estimates the price and expenditure elasticity of cigarettes. As expected, the results were that the consumption of cigarettes was reduced by 18%; however, the cigarettes could have been illegally imported, and therefore the reduction of 18% would most likely be a few percent lower. The possibility of illegal importing has not been factored into the model especially with big illegal imports coming from neighbouring countries. This large tax hike has shown that this will dissuade non-smokers from beginning to smoke in the first place, as seen in Sharbaugh et al. (2018).

Keneggarpanich et al. (2016) show that after a 9.7% cigarette tax increase, 48% of consumers decreased their cigarette consumption or altered their preference from premade to roll-your-own cigarettes. This increase in tax forces consumers to change their preferences if they still want to consume the same number of cigarettes. If instead, the direct fiscal cost outweighs the benefit, which is, in this case, enjoyment of smoking, then the consumer will stop altogether. However, Stehr (2005) states that large tax hikes can also cause individuals to order cigarettes online or travel to other states at a relatively lower price. As of the start of 2007, 67% of states had delivery laws on cigarettes to reduce the problem of individuals buying cigarettes from different states for a cheaper price (Chriqui et al. (2008)). If an individual has purchased a tax-free item online in the United States of America, they are supposed to report the purchase to the state tax agent who will then work out the tax that is on the good and directly charge it to the individual. However, this is not strictly enforced, and as a result, many sales often are hidden and not reported. The main problem with this is that it is in the United States of America, where different states have different taxes on cigarettes; however, in the UK, the tax rate on cigarettes is flat in all counties. Stehr (2005) also goes on in his paper to mention that effective policies need to be paired with a tax increase for there to not be a large amount of tax evasion; an example of this would be a more severe punishment for smuggling cigarettes over the border or through customs. The UK cigarette black market in 2016-2017 was valued at £2.5 Billion by (Her Majesty's Revenue and Custom) HMRC, which shows that there is a significant black market for cigarettes. This is more than likely due to the extremely high tax rate compared to the rest of the (European Union) EU. According to the tobacco manufacturers' association, the UK has the highest rate of taxation within the EU, which leads to more individuals buying cigarettes illegally to get around the high prices. Additional research by governments and tobacco firms to find different ways in which this



 
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black market can be eliminated is key to increasing the level of revenue by the government to pay for the health costs of smoking.

### Is Cigarette Tax Progressive or Regressive

Regressive taxation is where the amount of tax is a relatively higher percentage of a low-income individual's disposable income than a high-income individual, according to Vickrey (2008). Therefore, regressive taxation impacts the poor more than the rich. As Colman (2004) states, individuals who are not as wealthy are more price-sensitive than wealthy individuals, and therefore the tax increase would have a more negative effect on the former. Similarly, Remler (2004); Goldin (2011) find that the traditional economists' view is that cigarette taxes are very regressive as the tax significantly affects the poor, whereas the rich are less affected.

In contrast, progressive taxation is where the "amount of tax paid as a proportion of the tax base rises with that base" (Vickrey, 2008, P1). However, under specific behavioral economic models, taxes to a small number of smokers can be progressive when using "extreme elasticity estimates" (Colman, 2004, P4).

Additionally, Remler (2004) finds that as lower-income individuals are more price responsive, as aforementioned, they would be more likely to cut back on how many cigarettes they smoke or quit altogether. If the difference in the lower-income consumers' tax expenditure is lower than the difference in the higher-income consumers' tax expenditure, the tax would be progressive. However, this is unlikely to occur as it is unrealistic, given real-world consumer behaviour. Also, alongside tax increases, government policies may be connected; for example, counter-advertising on cigarette packaging may cause a large deterrence in smoking, which has not been accounted for in the model above.

### Price Manipulation

Only a select few cigarette companies control the market; this is called an oligopoly. Price and product manipulation within markets can cause many problems when governments attempt to raise prices by raising taxation. The firms can manipulate their product, which will lead to the firm not needing to reduce their price.

The cigarette firms are divided into high-end and low-end manufacturers consumed by high-income and low-income individuals, respectfully. Becker (1994) finds that many cigarette firms



 
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will manipulate the price even when the government has not put another tax on cigarettes. This is shown by Hiscock et al. (2017): high-end firms will pass on the tax and add a small amount on top, which is disguised as a hidden increase. This increase causes the price of cigarettes to exceed the value of the tax increase. The firm can raise its price artificially, as cigarettes are addictive and have an inelastic demand. This is shown as a 10% price increase in cigarettes that have been directly passed onto consumers and leads to an average 4% reduction in consumption (Bader et al. 2011). Consumers will still buy the good to a certain extent; this occurs predominantly in the higher-end cigarette manufacturers due to the high inelasticity (Wasserman et al. 1991).

Alternatively, Hiscock et al. (2017) state that in serving lower-end markets, cigarette firms will absorb the tax increase as the elasticities are different in the medium and high-end markets, as portrayed by Goodchild et al. (2016). If the demand is inelastic and the supply is elastic, the cigarette tax will be passed directly to the consumer, and the tax increase would come out of the consumer surplus. However, if the supply is inelastic, then the tax increase will come out of the cigarette firms' (producer) surplus. If the cigarette submarket is inelastic, then the cost is either directly absorbed by the producer or passed to the consumer in another way. Many of these ways are seen in Hiscock et al. (2017), and they include reducing the weight of tobacco packs or reducing the number of cigarettes in a pack by one to combat the tax increase. The consumer will still buy the cigarettes for the same price, but there will be one or two fewer cigarettes per pack. Additionally, to add value, firms will bundle certain products together, especially with roll-your-own cigarettes, to make it seem as if the consumer is saving money.

This is, however, a necessity for the lowest-priced products. As a result, the cheapest cigarette brand will get most of the lower-income market, as shown in Hyland et al. (2005). This is due to the ease of substitutability within the market. Low-income consumers will generally buy the cheapest variant of cigarettes even if that means purchasing illegally, which often happens (Hyland et al. 2005). As a result, people are less likely to quit if there is an easily accessible and cheap product black market. The black markets are more easily reachable in Asia, according to Lee et al. (2005).

Legally there are many different substitutions for a cigarette pack of 20, such as roll-your-own cigarettes and E-Cigarettes. The substitutes for cigarettes can affect cigarette consumption in



 
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varying degrees. Over time, the most popular substitute for pre-rolled cigarettes has altered from roll-your-own cigarettes to E-Cigarettes. This is seen in Caponnetto et al. (2013); it was found that smokers who do not want to quit smoking value E-cigarettes as a good substitute for cigarettes.

### Summary of the Literature

The literature investigating cigarette consumption covers a variety of different areas, not only economics. All the findings from the literature are conclusive that an increase in taxation leads to a decrease in consumer consumption. The level of the reduction in consumption, however, depends on the socio-economic background of the individual. Firms can get around the problems of increasing tax rates by manipulating their cigarette packs, and as a result, their product can remain cheap and competitive.

### Data Description and Sources

The data for the daily consumption was sourced from the Office of National Statistics (ONS). It is comprised of data gathered between 1980-2018. However, the data was only collected on the even years between 1980-2000; therefore, the odd years in that date range were calculated as an average of the year before and the year after. The daily consumption was then multiplied by the number of days in that year and considered leap years. The average price per 20 cigarettes was from the ONS and between 1987-2017. There was not another reliable before 1987. The GNI PPP (Gross National Income-based on Purchasing Power Parity, using the Atlas Method) was from the World Data Bank, which was converted from US Dollars to Pounds, spanning from 1962-2018. The percentage of the rural population was also from the World Data Bank and has data from 1960-2018. However, only data from 1980-2018 was needed, as the average price restricted the years able to be used. The tax amount was sourced from the tobacco statistics tables by HMRC. The tax amount was per 1000 sticks; it was then equated to the same number of cigarettes per pack, which is 20 by dividing it. This data is from 1978-2018. I researched all policies on the government's legislation website and selected all articles relating to tobacco between 1980-2018. If the policy affected the quantity or price of cigarettes, it was regarded as a relevant policy.

Due to certain data limitations, the average price sample is from 1987-2017, which leaves 31 annual observations. All data used is based on the United Kingdom, which includes Northern Ireland, England, Scotland, and Wales.



 
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*Table 1 - List of Variables*

| Variable Name | Meaning | Source |
|---|---|---|
| C | The annual cigarette consumption per person in the UK. | ONS |
| P | The price level after it has been decorrelated from taxation in the UK. | ONS |
| GNI | Gross National Income per person in the UK. | The World Data Bank |
| Rural | The percentage of individuals who live in rural areas in the UK. | The World Data Bank |
| Pol | The number of policies that affected tobacco consumption/ production excluding taxation | GOV Legislation |
| Tax | The amount of taxation on cigarettes in the UK in Pounds Sterling. | HMRC |

$$ln\ C_t = \beta_{1t} + \beta_2 P_t + \beta_3 LnGNI_t + \beta_4 Rural_t + \beta_5\ Tax_t + \varepsilon_t \quad (1)$$

t (years) where t = 1, 2, 3 … 31

The data collected created a cigarette demand model, with one dependent variable and five independent variables. The dependent variable (*Ct*) is the annual consumption of cigarettes per capita. This is measured by calculating how many cigarettes are smoked a year and dividing it by the population to get an average number of cigarettes smoked per capita at time t. The independent variables chosen are the price of cigarettes in the UK, the GNI (Gross National Income) per capita for the UK, the percentage of the rural population in the UK, the number of policies created by the UK and EU (European Union) that would affect cigarettes, and the amount of tax on cigarettes. (*Pt*) Price is the average price of a 20 pack of cigarettes at time t; this has been taken away from tax at time t to eliminate the collinearity between the two variables. (*GNIt*) GNI PPP (Gross National Income per capita) is the value of a country's income divided by the population of the country at time t. (*Ruralt*) Rural is the percentage of people in the United Kingdom that live in a rural environment at time t. (*POLt*) is the number of policies created in time t that would influence cigarette prices either supply or demand, the lagged term will be a



 
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period for the effects to take place. (*Taxt*) Tax is the amount of tax that is added to the cost of a pack of cigarettes. This was initially per 1000 cigarettes; however, it was divided by 50 to align with the 20 per cigarette pack price at time t.

### Other Relevant Variables

E-cigarettes have been excluded as the data started in 2011, which would not allow enough data points to create a reliable time series data regression. The E-Cigarette data is an important variable as it would be able to show the change in E-cigarette consumption and its potential impact upon cigarette consumption. Another substitute omitted is cigars. After research, it was discovered that cigars were not a close enough substitute to cigarettes as originally thought. Other potential substitutes included nicotine gum which Shahan et al. (2000) find to be a weak substitute for cigarettes.

### Model and Methodology

The paper hypothesizes that cigarette taxation has a significant effect on cigarette consumption. The model used shares many similar variables to Yeh et al. (2017). However, in their empirical specification and analysis, they looked at the annual cigarette consumption per capita using data from 2005-2014, and they looked at the 28 European countries. My model looks at the annual cigarette consumption per capita only within the UK, which is similar to Yeh et al. (2017). Conversely, the model differs in some explanatory variables, these being the number of policies made by the EU; the UK regarding tobacco; and the amount of tax paid on a 20 pack of cigarettes. This differs from Yeh et al. (2017) who use the MPOWER measurement (effective interventions to reduce the demand for tobacco) and the cigarette prices of Eastern European countries. The variables in my model are now policies and taxation to make it more specific to the UK. The policy variable was included as the policies created by the EU and UK have direct and indirect effects on both the price and quantity supplied of tobacco within the UK. Therefore, this variable would have a significant effect on consumption. Taxation on cigarettes also affects consumption by altering the total price. However, the firms can choose whether they should artificially increase the total price on top of the taxation, therefore these variables are different.

Formula (1) is a log-linear demand model, which has been regressed using OLS with robust standard errors. The OLS will identify if there is a correlation between the explanatory variables (Price before tax, GNI, Rural, Tax) and the dependent variable (annual cigarette consumption per



 
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capita). The OLS tests will first be run; then, several other robustness tests, including the Durbin-Watson (DW) test, which tests for autocorrelation, and the White Test, which tests for heteroscedasticity, will be run.

Adapted demand model formulae:

Formula (2)

$$ln\ C_t = \beta_{1t} + \beta_2 LnPt + \beta_3 LnGNI_t + \beta_4 Rural_t + \beta_5 LnTax_t + \varepsilon_t (1)$$

t (years) where t = 1, 2, 3 … 31

Formula (3)

$$ln\ C_t = \beta_{1t} + \beta_2 P_t + \beta_3 LnGNI_t + \beta_4 Rural_t + \beta_5 Tax_t + \beta_6 POL_t + \varepsilon_t (1)$$

t (years) where t = 1, 2, 3 … 31

Formula (4)

$$ln\ C_t = \beta_{1t} + \beta_2 P_t + \beta_3 LnGNI_t + \beta_4 Rural_t + \beta_5 Tax_t + \beta_6 L1POL_t + \varepsilon_t (1)$$

t (years) where t = 1, 2, 3 … 30

Formula (5)

$$ln\ C_t = \beta_{1t} + \beta_2 LnP_t + \beta_3 LnGNI_t + \beta_4 Rural_t + \beta_5 LnTax_t + \beta_6 POL_t + \varepsilon_t (1)$$

t (years) where t = 1, 2, 3 … 31

Formula (6)

$$ln\ C_t = \beta_{1t} + \beta_2 LnP_t + \beta_3 LnGNI_t + \beta_4 Rural_t + \beta_5 LnTax_t + \beta_6 L1POL_t + \varepsilon_t (1)$$

t (years) where t = 1, 2, 3 … 30



 
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## Analysis and Results

*Table 2- OLS for annual cigarette consumption per person*

| Dependent variable: LnC | Regressions | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Independent Variables | | | | | | |
| $\beta_1$ | 8.1767*** | 6.7275*** | 8.1680*** | 8.1366*** | 6.729*** | 6.5784*** |
| | (0.2336) | (0.2323) | (0.2330) | (0.2986) | (0.2370) | (0.2425) |
| P | -0.0223 | | -0.0242 | -0.0223 | | |
| | (0.0156) | | (0.0259) | (0.0276) | | |
| LnP | | -0.0385 | | | -0.0425 | -0.0459 |
| | | (0.0578) | | | (0.0590) | (0.0581) |
| Rural | 0.0075 | 0.0377*** | 0.0077 | 0.0082 | 0.0378*** | 0.0387*** |
| | (0.0081) | (0.0067) | (0.0094) | (0.0109) | (0.0067) | (0.0070) |
| Ln(GNI) | 0.0358*** | 0.1089*** | 0.0360*** | 0.0383** | 0.1087*** | 0.1223*** |
| | (0.0139) | (0.0224) | (0.0105) | (0.0132) | (0.0230) | (0.0234) |
| Tax | -0.0604*** | | -0.0578** | -0.0599*** | | |
| | (0.0157) | | (0.0226) | (0.0221) | | |
| LnTax | | -0.0838* | | | -0.0796 | -0.0794 |
| | | (0.0433) | | | (0.0472) | (0.0430) |
| Pol | | | 0.0006 | | 0.0005 | |
| | | | (0.0014) | | (0.0020) | |
| L1.Pol | | | | -0.0001 | | -0.0007 |
| | | | | (0.0015) | | (0.0019) |
| N | 31 | 31 | 31 | 30 | 31 | 30 |
| $R^2$ | 0.9772 | 0.9643 | 0.9774 | 0.9764 | 0.9664 | 0.9651 |
| $R^2_{adj}$ | 0.9737 | 0.9599 | 0.9729 | 0.9714 | 0.9572 | 0.9579 |
| DW | 2.36 | 1.70 | 2.35 | 2.36 | 1.68 | 1.89 |





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N = Number of Observations

*=10% significance level

**=5% significance level

***=1% significance level

Robust standard errors in parentheses

DW = Durbin-Watson test

By using the estimated Equation (1) and computing the OLS with robust standard errors, I aim to observe how significant a change in taxation affects smoking behaviour, which is measured by the consumption level. The regression shows that price and taxation are negatively correlated. This was expected as all literature pieces support this relationship.

The two tests differ as regression 1 is log to levels, and then regression 2 is log-to-logs. The elasticity of demand for regression 1 is slightly higher. The regression shows that the estimations are both inelastic. This means that as the price increases, the quantity demanded decreases. The estimates are close to perfectly inelastic demand (=0) where consumers will always buy the good, no matter if the price increases significantly or not. However, there are several issues with the elasticity estimates, specifically, the addictive nature of the cigarettes combined with the aggregated cigarette consumption data. Additionally, the estimates assume that everyone consumes a non-zero amount of the good; we know this is not the case with cigarettes.

The remainder of the tests is slightly different. Regression 1, 3, and 4 are very similar, as Policies (Pol) were added and Policies were lagged over one period, respectfully. Regressions 2, 5, 6 were log-to-logs. In regression 5, the variable Policies were added, and in regression 6 the Policies were lagged over one period. The log–level regression is slightly more negatively correlated according to the Durbin-Watson test. The log-log regressions are slightly more positively correlated over time, as seen in the table.

*Table 3 - Comparison of regressions*

| Data Source | High Elasticity of Demand | Low Elasticity of Demand | Author |
|---|---|---|---|
| Global | -0.25 | -0.5 | Goodchild et al. (2016) |



 
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| Data Source | High Elasticity of Demand | Low Elasticity of Demand | Author |
|---|---|---|---|
| Taiwan | -0.14 | -2.23 | Lee et al. (2005) |
| Europe | -0.50 | -1.23 | Yeh et al. (2017) |
| UK | -0.0223 | -0.0459 | My estimate |

The use of control variables is important in the model, as they help separate the effects to show the relationship between important variables and the dependent variable. Within the model, there are several controlled independent variables to investigate and observe the relationship between the price and cigarette consumption. These independent variables are Price, GNI, Rural and Policies, which all help to explain the model, but also help separate the effect out to see the true value of the relationship.

Yeh et al. (2017) find that a 10% level of increase in cigarette price leads to an average decrease of 7% on the level of cigarettes consumed. However, in regression 1, my model regression shows that a 10% increase in cigarette prices leads to a 21.4% decrease in cigarette consumption, which is a lot larger than expected after researching many other pieces of literature. This can be attributed to the fact that in Asia, the United States of America, and Eastern Europe the black markets are more prominent. This is because the supply chains can easily move illegal products around the countries. Asia produces a large quantity of tobacco, which is then sold at cheaper prices to counterfeiters who will mix the tobacco with other products; this effectively reduces the amount of tobacco contained to create a cheaper alternative. Within Eastern Europe, the prices of cigarettes are considerably lower, and therefore an increase in the price by a percentage is not as impactful. The United States of America has different cigarette taxation levels depending on the state, which means individuals can travel and easily buy cigarettes cheaper in other states. This is not possible in the UK, as seen by Stehr (2005). In Goodchild et al. (2016), a simulation of a $1 increase reduced low country income groups consumption by 32%, which is higher than my model's estimation. This is probably since countries with low-income groups are more likely to reduce their consumption legal consumption and buy illegally instead. This is because their disposable income is limited, and they are more price sensitive. Therefore, the simulation estimate is more likely to be closer to my model's estimation. Lee et al. (2005) find that an increase of approximately 20% in the price of taxation leads to an 18% reduction in the number of cigarettes



 
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consumed. With such a significant price increase, and using other literature pieces as a guideline, we would expect to see a greater decrease in consumption than 18%. However, as Taiwan is very close geographically to China, which produces the largest quantity of tobacco in the world, the country has easy access to the Chinese black markets. Taiwanese people may already buy from China and not from Taiwan at all, which would mean the increase in taxation would only affect wealthier individuals who still bought cigarettes legally. The price increase would lead to a smaller decrease in consumption than expected. The estimation by Keneggarpanich et al. (2016) differs from the rest of the literature as it uses roll-your-own cigarettes data, which has a completely different subset of users. Generally, if you roll your own cigarettes, then you are more conscious of money, as it is significantly cheaper; therefore, such people are more price sensitive. As we see in his estimation, a 9.7% increase in cigarette taxation causes 48% of consumers to either decrease their consumption or switch what type of cigarettes they consume from premade to roll-your-own. The test conducted differs from most other available literature pieces as it does not look at cigarette consumption in isolation but looks at the change between subsets as well. This is likely to have a similar estimation to my model, where most people switch from premade to roll-your-own, and then a smaller estimated percentage of 15/20% stop smoking altogether. This shows that there is a significant substitution effect when the price of cigarettes is increased: many individuals will start to use roll-your-own cigarettes.

There are several limitations, such as the small data set; this could have been altered if the data from the Office of National Statistics was measured quarterly rather than annually. This may lead to outcomes that may exacerbate the estimation. There is a lack of accurate data for the black market in the UK; this means that estimates are higher than they should be. There was also a lack of data for E-cigarette sales before 2014, which reduced the number of variables in my model. To avoid heteroscedasticity, I ran tests to reduce the serial correlation using the Durbin-Watson test. By doing the Durbin-Watson test for this formula, the value was 2.36, which is a very weak negative autocorrelation; this means that if the value before dropped, there would be a greater likelihood that the value would rise in the following year. To lower the heterogeneity of the residuals, the White Test will be used. Additionally, the robust standard errors will reduce the heteroscedasticity in the model. The statistical software used to perform the regression and further tests were Stata.



 
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### Addictiveness Estimates

While using Keeler et al. (1993) estimation with rational addiction, as price increases by 10% this causes a 28% decrease in the demand for cigarettes. However, the regression without rational addiction showed a 35% decrease in consumption when the price increased by 10%. To relate this to my model, I observed the difference between the two estimates from Keeler et al. (1993) as a 25% reduction in consumption when the addiction model is applied. With this estimate applied to the regression run by my model, a 10% increase in price would cause a 16.05% decrease in consumption, factoring in rational addition. My original regression without addictiveness applied was a 10% increase in price, resulting in a 21.4% reduction in consumption. The difference is approximately 5.3%, which shows that addicted individuals are less likely to reduce their consumption when the price increases.

### Socio-Economic Estimates

Following Sharbaugh et al. (2018), as cigarette prices increase by approximately 4% from the 0.25$ increase, cigarette consumption decreases by 0.6%. If it is equated to a 10% increase in price, then the consumption would decrease by 1.5%. In the youngest category, 18-24 year old's, a 10% increase causes a decrease in consumption of 3.75%, which is more than twice more than Sharbaugh et al. (2018) original estimation. Using this basis for an estimation on my model, the youngest individuals would reduce their consumption by 54%. Whilst this reduction is significant, the average price of cigarettes in the United States of America is considerably lower than in the UK. This price difference causes the consumption to vary more drastically; the assumptions are that the price differences do not affect the consumption levels significantly. The estimation by Sharbaugh et al. (2018) is unrealistically large and the decrease in consumption will predominantly be consumers switching to substitutes products, such as E-Cigarettes or roll-your-own cigarettes.

The lower-income individuals (<$25,000 a year) have little sensitivity to the price increase as a 10% increase leads only to a 0.25% decrease in consumption; however, all the other income groups have an average decrease in consumption of 1.7%. The difference in cigarette consumption when there is a 10% increase in price results in the lower-income individuals not changing their consumption as much as the other income groups do. The change in consumption in different



 
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income groups could be attributed to the difference in what income level is counted as at the lower income.

### Financial Implications of a Reduction in Consumption

My model estimated that in 2017 the UK made approximately £16.7 billion in tax revenue from cigarettes. This was done by multiplying the percentage of smokers in the UK by the population in 2017. Then this calculation was multiplied by the taxation per pack of cigarettes.

However, when the cigarette tax is increased by 10%, the cigarette tax revenue decreases by 20% to £13.2 billion. Additionally, an estimated 2.7 million people stopped smoking from the tax increase. My model estimated that a 10% price increase leads to approximately 2.7 million people reducing their cigarette consumption, which was 21.7% of smokers in the UK; this was approximately 14.5 million people. The new lower number of smokers multiplied by the taxation per pack of cigarettes which has increased by 10% (assuming that taxation is directly passed on to consumers) will show the new tax revenue. It is difficult to consider the number of individuals that are made unemployed within the tobacco industry in response to the reduction in cigarette consumption.

In 2017 the government's tobacco control plan estimated that the cost to the economy (NHS, economy, environmental, other second-hand smoking factors) was approximately £11 billion a year. Given a reduction of smokers by 2.7 million, this would reduce the total economic cost to approximately £8 billion. Dividing the cost of the economy by how many smokers there were in 2017, then multiplying that number by the new level of smokers, gives an approximate cost to the economy.

However, the effects of those 2.7 million people stopping smoking are not instant, and many health problems would persist. Furthermore, many factors are not considered, such as the environmental impact, the productivity levels of not smoking every 15 minutes, and the improved concentration from not smoking. The number of individuals who will buy from the black market instead of shops after the tax increase is not currently calculatable.

### Limitations

The limitations of the model were that the data for E-Cigarettes, which was originally included within the model did not have enough data points to put into the model. Additionally, there was



 
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not any reliable data before 1987 for average cigarette prices. The missing six years reduced the whole model by six observations. I did write an email to the Office of National Statistics, unfortunately they did not have any additional data that would be relevant. Additionally, the data on the size of the black market for cigarettes is another limitation, as other research papers in Asia have lots of data to predict the size of the black market and to then take it into account within their model.

## Conclusion

In conclusion, the estimation of the model in the project has a slightly higher than expected reduction in cigarette consumption. However, this can easily be explained by economic reasoning. My model regression shows that a 10% increase in total cigarette prices leads to a 21.4% decrease in the consumption of cigarettes consumed. The paper aimed to analyse the relationship between cigarette taxes and smoking behaviour, which in this case is the level of consumption. Specifically, the focus was on the effects of taxation within the UK this was done by looking at time series data between 1987-2017.

The OLS test was used to see if there was a significant relationship between cigarette taxation and cigarette consumption. The regression shows that there is a negative relationship between cigarette taxation and cigarette consumption. The results are that the cigarette tax has a negative correlation with cigarette consumption; consequently, as cigarette taxation increases, cigarette consumption decreases. The challenges that arose within testing were the problems with collinearity and the heteroscedasticity of the model. To rectify this issue, I used several tests and reformulated certain variables to limit the collinearity. Additionally, to deal with the heteroscedasticity, robust standard errors were used, which limited the heteroscedasticity in my model. In addition, the White Test was run to ensure that the heteroscedasticity in my model was not significant. The final challenge was the fact that the data was collected annually; therefore, there were not many observation points, which is difficult in time series models and could potentially alter the results.

The results gathered from the data and the model echo the reading of other literature. However, further empirical research is required for gathering more data points and discovering other relevant variables. Although policies were seen to be insignificant in my model, it is difficult to



 
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value each policy in importance. Many policies, including the ban on smoking inside buildings, have had substantial effects on consumption along with the ban on cigarette advertisement. To further this study, a more detailed look into pairing policies with taxation and seeing the effects of it would explain the model better. Additionally, it would also be useful to compare the results with a similar country where taxation is the same throughout the whole country and the black-market influence similar to that in the UK. There could be more data for relevant substitutes throughout the dataset which would allow the effects of the cigarette substitutes to be observed and to see if it is significant on the consumption levels. These adaptations would give more of a holistic view of the effects of cigarette taxation on consumption and whether simply just taxation is enough in combatting the problem of smoking.

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