Examiner's commentary

This essay is commendable in the way in which it communicates accurately and effectively the purpose and focus of the research, as well as making the research process very clear. The knowledge and understanding of the economic concepts involved is also commendable. It is refreshing to see a candidate realizing that electric cars do not have positive externalities of consumption but, instead, may reduce the negative externalities created by combustion engine cars. This realization demonstrates a clear understanding of the topic. The conclusions presented are impressive in the way that they do support the claims that electric cars will have been responsible for some fall in emissions, while realizing that the relatively small number of electric cars means that the effect will not, in the short run, have been very significant. Indeed, throughout the essay, it is refreshing to see such awareness of the possible limitations of the research and of the arguments: such as the possibility of time lags; the existence of other influential factors, such as population changes or the heating of homes; and the awareness of the accuracy of the geographical data.

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The effect of UK Government policies regarding electric cars on air pollution in central London

To what extent have the UK Government's interventions in the electric car market led to a decrease of PM10 emissions in central London?

Economics

3998 words

Table of contents

1. Introduction

PM10 particulates, or PM10, are small particles of mainly carbon released into the air during incomplete combustion and a major component of air pollution in cities, posing one of the greatest hazards to human health[1]. Consequently, reducing emissions of such pollutants in our cities is one of the greatest challenges that our society faces, and one of the most popular and widespread ways of attempting to do so is by popularising electric cars. In this research project the aim will therefore be to investigate how effective government policies regarding electric cars in the UK (specifically purchase incentives, subsidies to producers and advertisement) have been at reducing PM10 emissions produced by cars in central London.

It was decided that PM10 in particular would be investigated because they have atrocious health effects, meaning that reducing PM10 particulate emissions might be one of the most significant effects that the policies might have had, if they are shown to have had an effect. Central London has been chosen in order to carry out this investigation because it has large amounts of traffic flow and congestion, consequently PM10 are likely to be more concentrated in areas such as this one; and since PM10 have such a significant negative impact on individuals' health, a key measure of the policies' success at reducing the negative effects of combustion engine cars is whether they can effectively reduce PM10 in central London.

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1 http://www.bbc.co.uk/schools/gcsebitesize/science/21c_pre_2011/atmosphere/whathappenstopollutantsrev1.shtml

This research will be closely linked to economic theory regarding negative externalities of consumption, in particular that of combustion engine cars, and ways through which they can be addressed. Specifically, I will investigate how effective the government's interventions in the electric car market were at moving the market for combustion engine cars closer to the social optimum and decreasing their negative externality of consumption, by increasing demand for electric cars. This would mean that consumers would switch from combustion engine cars to electric, decreasing the number of non-electric cars circulating and hence reducing the value of the externality.

2. Background information

2.1 The externality of combustion engine cars

As previously mentioned, combustion engine cars have a negative externality of consumption, as there's an extra cost to third parties as a result of their use. This is because they lead to serious environmental issues, since they emit air pollutants which are hazardous both for the environment and human health. For instance, PM10 lead to lung inflammatory reactions, reduction of lung functionality, increased mortality and hence a lower life expectancy[2]. Consequently, such cars have a larger Marginal Private Benefit (MPB, benefit that results from consuming one extra unit of the good as received from the entity consuming the good)[3], than Marginal Social

[2] https://diamondenv.wordpress.com/2010/12/10/particulate-pollution-pm10-and-pm2-5/

[3] http://regulationbodyofknowledge.org/glossary/m/marginal-private-benefit/

Benefit, (MSB, benefit for society from consuming one extra unit of the good), as shown in Figure 1:

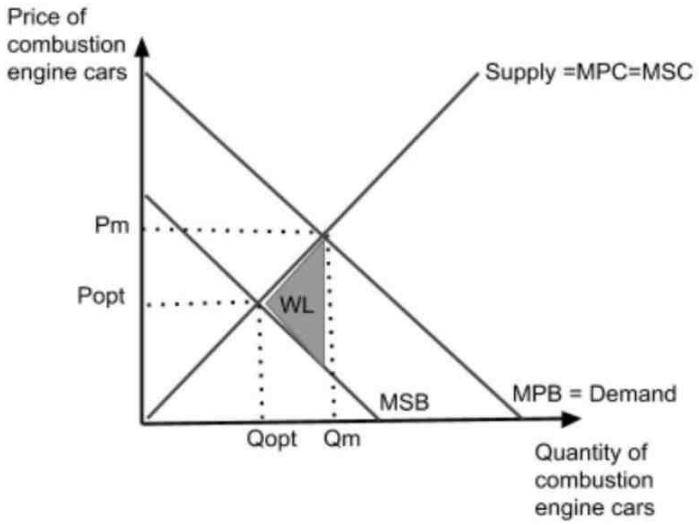

Figure 1: Diagram showing the negative externality of combustion engine cars.

As we can see, the quantity at which the market is operating is larger than the optimum quantity (Qm > Qopt). Therefore, there's overallocation of resources and allocative inefficiency, since more resources are being employed for the production and consumption of combustion engine cars than what is socially most desirable; thus, there's market failure[4] as the allocation of goods and services is not efficient. Moreover, there's welfare loss (WL), arising from the loss of social benefits due to the overproduction of the good when operating at the market level, and from MSC exceeding MSB at the market equilibrium.

The British Government needed to address this allocative inefficiency and market failure by reducing consumption and production of combustion engine cars, hence also reducing the overallocation of resources, as by doing so the amount of

[4] Ellie tragakes (2009). ECONOMICS for the IB Diploma . (2nd ed.). United Kingdom: Latimer Trend

polluting emissions produced in their cities would be reduced, thus so would the negative externality. There are several ways by which this could be done by influencing directly the combustion engine car market, such as through taxation on cars' carbon emissions. However, in this investigation I will focus on government policies aimed at the expansion of the electric car market in order to increase the use of such cars and encourage consumers to switch from combustion engine cars to electric, consequently decreasing the amount of combustion engine cars used as well as PM10 emissions.

2.2 Government interventions in the electric car market

2.2.1 The Plug-in Car Grant

The Plug-in Car Grant[5] was introduced by UK's government on the 1st of January 2011, although in this investigation it will be analyzed and evaluated from 2013 because economical factors that happened before 2013 are likely to not be significant in the present. The grant provides a discount of 25% towards the cost of new electric cars, with a maximum discount of £5000. On April 1st 2015 the price cap was raised to cover a discount of up to 35% of the car's retail price.

2.2.2 Grants and subsidies to producers

The second policy that will be taken into account is the various grants and subsidies to producers that the government has granted, with the aim to both increase production and consumption of electric cars and encourage technological

[5] https://www.gov.uk/plug-in-car-van-grants

advance. In March 2013, the largest car factory in the UK, Nissan, was given a £20.7 million grant by the British government[6]. Additionally, the government allocated £400 million to support the deployment of electric cars[7]. By September 2013, £92 million of the original amount had been spent, coupled with an additional £44 million given to projects up to 2015.

2.2.3 Advertising

The UK government launched an advertising campaign in January 2014, called Go Ultra Low[8]. It's aim was to increase the appeal of electric cars to consumers by promoting their benefits and advantages. The government carried out this campaign in partnership with five major electric or plug-in car producers, and the campaign, which is still going today, is estimated to have had a cost of £9 million.

3. Methodology

In order to carry out this investigation, data on both demand for electric cars and concentrations of PM10 over the years in central London will be obtained; starting from 2013 and following up to 2018, which is when the last set of data was recorded. This will thus allow me to look for trends and see if the policies led to consumers switching to electric cars, and whether the changes in their demand are correlated with the concentrations of PM10 in central London, since if it's a negative

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6 https://europe.nissannews.com/en-GB/releases/release-6480-nissan-to-build-leaf-electric-vehicle-in-sunderland#

7 http://researchbriefings.files.parliament.uk/documents/CBP-7480/CBP-7480.pdf

8 https://www.goultralow.com

correlation the policies will most likely have had an effect. If any trends are spotted, outside factors which could have caused the trends, other than electric cars, will need to be considered.

The PM10 concentrations data for central London will be of both the areas of Westminster and City of London, as they can be thought as to being a good representation of the centre of London regarding amounts of traffic, and hence emissions from engines, since they are the main and largest components of the centre. Data was collected by London Air, a website operated by the prestigious organisation King's College London that records data on air quality in London. Therefore, using London air ensured the reliability of the data. I will use data from three measuring stations throughout each of the two areas, so 6 in total, spread around a range of streets that will be representative of the totality of the area, since they aren't close to each other. Measurements were recorded with a daily mean, from 2013 to 2018, but to better appreciate trends in the data I will group it into months.

The data for electric cars will for be electric cars circulating, as demand for electric cars directly influences electric cars circulating so the two are equivalent. It will be obtained from a report done by the UK government, again to ensure reliability. Data will be for the entirety of London and not the centre only, as data for the centre is private. However, since the centre is the main part of the city, containing most of the traffic, we can assume that the trends in the number of electric cars circulating through London will be mostly equivalent to the trends in the number of electric cars circulating through the centre.

4. Analysis of data

In this section data will be analysed as according to the methodology.

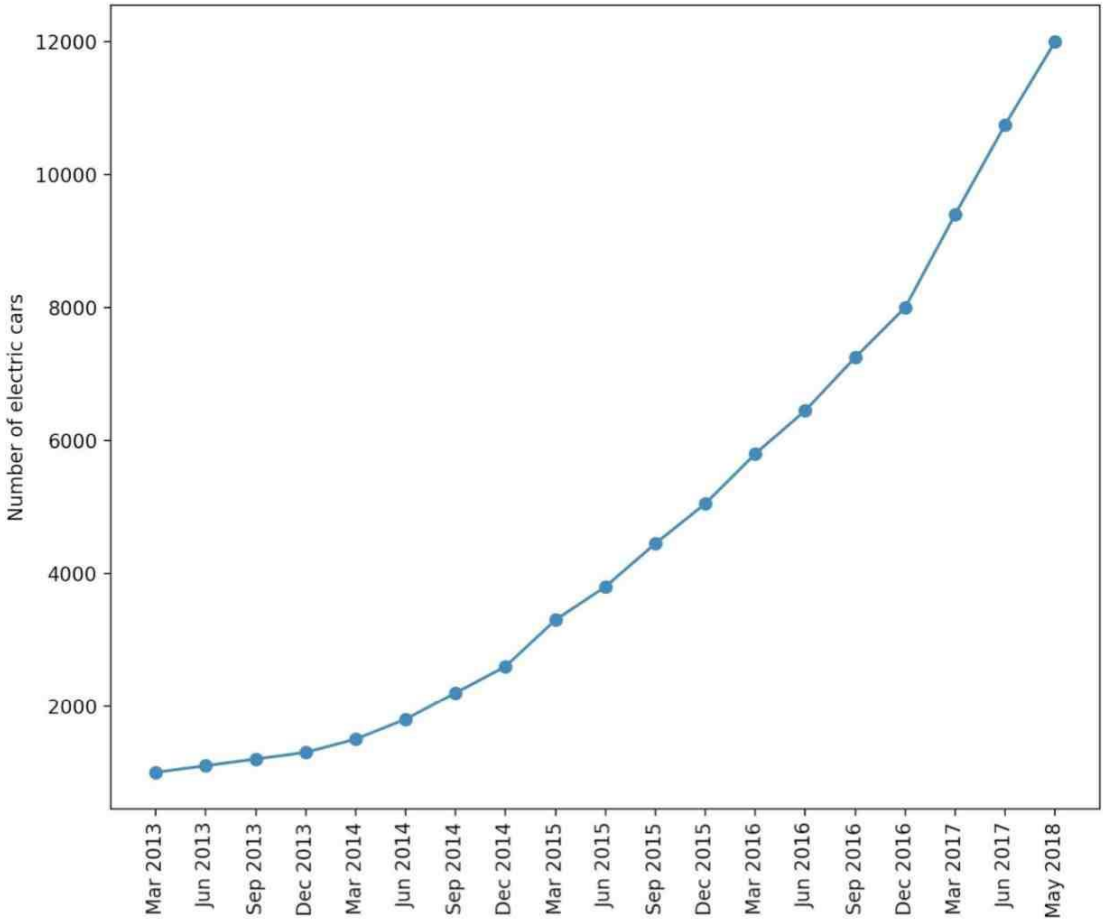

Figure 2: Graph showing the number of electric cars circulating in London[9].

As shown in Figure 2, there was a steady increasing trend in electric cars circulating from March 2013 to March 2014. At this point the Plug-in Car Grant was in place, aiming to increase demand for electric cars by giving a significant discount, hence providing incentives for consumers to switch from combustion engine cars to

[9] https://www.london.gov.uk/sites/default/files/environment_committee_-_ev_report.pdf

electric cars. Time lags of this policy would not have been significant because by 2013 it had been in place for over two years, hence it's likely to have been one of the main factors that increased the number of electric cars circulating by 600 over this period.

The grants and subsidies to producers had also been introduced, specifically the grant to Nissan and the £174 million spent in other grants and subsidies targeting infrastructure and research and development. These increased production of electric cars, having the following effect:

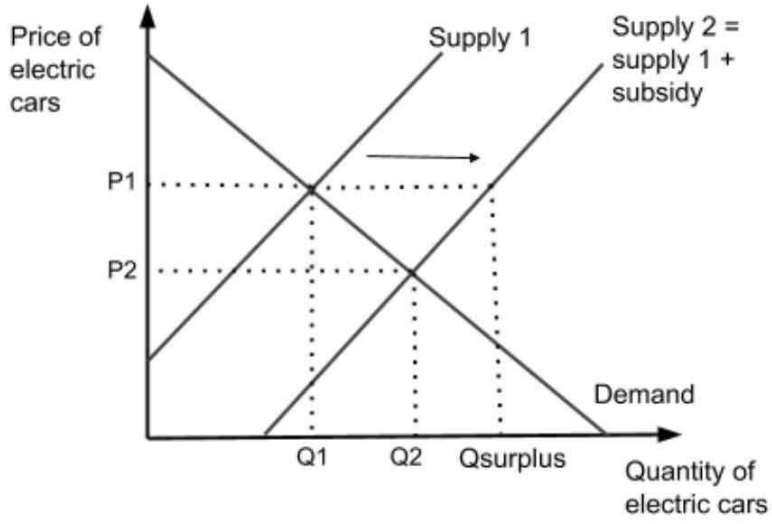

Figure 3: Diagram showing the effect of grants and subsidies to producers

As we can see, supply would increase as firms are now able to produce more at each price, because of the subsidy lowering firms' costs of production and the increased efficiency from the investment in research and development. This would lead to a surplus, putting a downward pressure on price, as producers would compete to sell to the limited demand, which would in turn send a signal to consumers and provide them with incentives to increase quantity demanded (Q1 to

Q2), whilst producers would supply less as the good would become less profitable (Qsurplus to Q2). Hence the market would move from the equilibrium (Q1, P1) to (Q2, P2). This means that a considerable amount of consumers (Q2 - Q1) would switch from combustion engine cars to electric, because of the lower price (P2 < P1) and the technological advances that increase the appeal of electric cars, such as better batteries with more driving range at Nissan and more efficient cars.

Nevertheless, the grants and subsidies would've had significant time lags. They require bureaucratic procedures, time to research and develop and firms adjusting factors of production to increase output. Consequently, they wouldn't have had an effect on March 2013 immediately after they were introduced, but later on. This is supported by the gradient of Figure 2 increasing very significantly from March 2014 hence leading to an increase of 1700 in the number of electric cars circulating from March 2014 to March 2015, almost three times the increase of the previous year. Hence this suggests that the grants and subsidies started to have a substantial effect after March 2014.

However, the Go Ultra Low Campaign was launched in January 2014, which would have further increased the effect and effectiveness of the other two policies by influencing consumer preferences and increasing the appeal and popularity of electric cars. Therefore, the increase that we see from 2014 onwards in Figure 2 is likely to also have been caused by the advertising campaign. The number of electric cars circulating continued to increase steadily over 2015 and 2016, although there is a small fluctuation in the gradient from December 2014 to June 2015, with the gradient increasing and then going back to the general trend. This could be because at that time consumers became eligible for a discount of up to 35% of the retail price,

due a change in the policy of the Plug-in Car Grant, as opposed to the previous 25%. This could have had a large effect, since the increase in the discount was done once the policy had been in place for four years and had been thoroughly advertised, thus it was likely that many consumers had come to know about it.

The previous culminated with an increase in the gradient of Figure 2 that led to an increase of 5000 cars from December 2016 to May 2018. This could be due to the action of all the policies acting together to create an increasing positive effect in the electric car industry, as the larger demand led to a need for a larger production of cars - which could be accomplished because of the subsidies given to the producers. This meant that more workers were needed, thus increasing employment in the industry whilst at the same time leading to technological advances which in turn continued to increase demand.

Therefore, demand for electric cars has increased steadily over the the last five years in a fashion that meets what would be theoretically expected from the policies. Hence, the government intervening in the electric car market by introducing the three policies has substantially increased demand and use of electric cars. This growth is sustainable and likely to continue over the future, as it's being met by efforts by the government to improve infrastructure, such as charging stations[10]. The increase in demand for electric cars is likely to have led to a significant number of consumers switching from combustion engine cars to electric cars. This is a non-price determinant of demand for combustion engine cars, change in consumer

[10] https://www.standard.co.uk/news/london/number-of-electric-car-charging-points-in-london-to-double-a3602891.html

preferences, that will have decreased demand for such cars, the effect that this had is shown below:

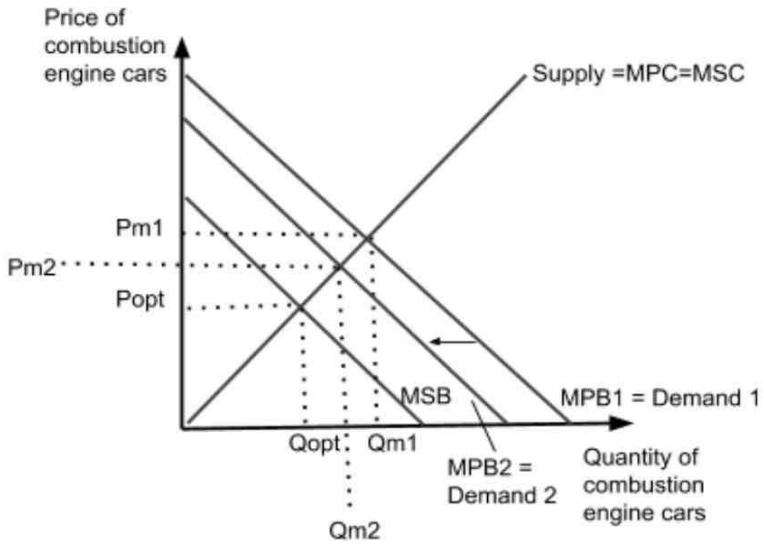

Figure 4: Diagram showing the effect of the policies on the negative externality of combustion engine cars.

As shown, there will be a shift of demand away from Demand 1 because the change in consumer preferences means that less will now be demanded at each given price level, reaching a new demand curve for combustion engine cars, Demand 2, which is closer to Marginal Social Benefit. Consequently, a new equilibrium (Qm2, Pm2) will arise closer to the optimum equilibrium (Qopt, Popt). Therefore, since the market is now operating closer to the social optimum, the value of the negative externality of consumption that combustion engines pose will be reduced, as less exhaust fumes, and hence less PM10, will be emitted. This is supported by Figure 5:

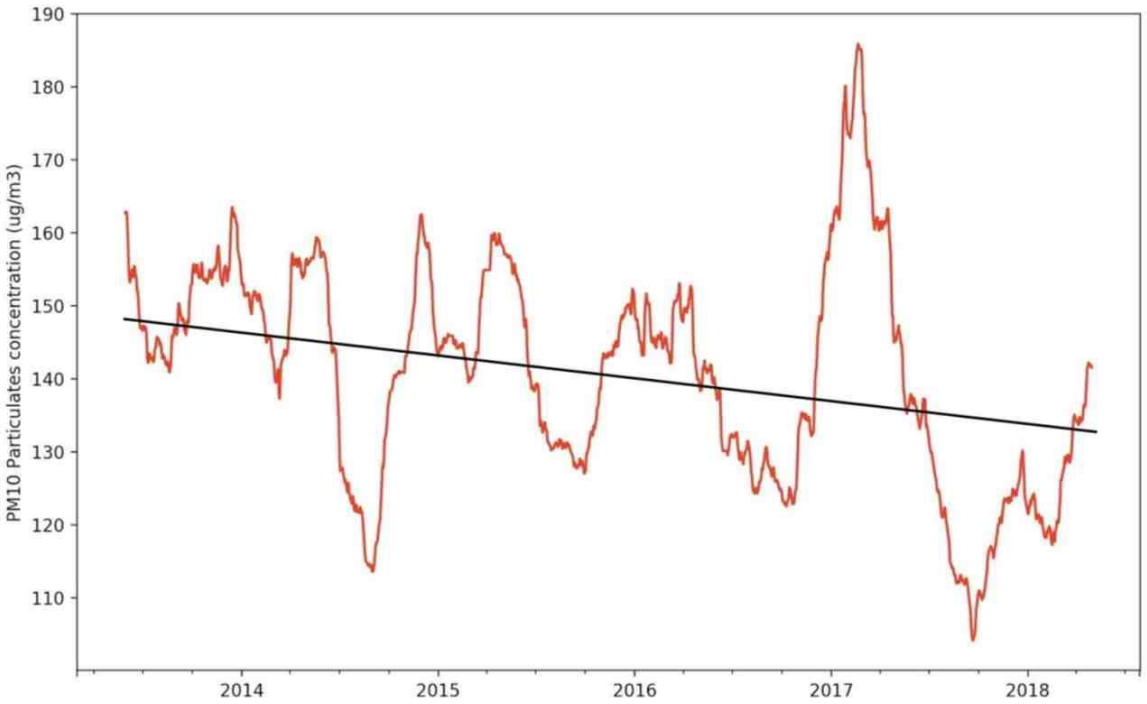

Figure 5: Graph showing PM10 concentrations in central London[11].

As we can see, there is an overall downwards trend that can be seen from the line of best fit in Figure 5. This would support the fact that the government interventions in the electric car market, that have been effective at increasing demand for electric cars, have also led to decreasing emissions of PM10 in central London due to consumers switching from combustion engine cars to electric cars. However, there are some significant peaks and throughs in the concentrations which need to be considered.

In the fluctuations in concentrations from 2013 to 2015, we can see that they match the changes in demand for electric cars (that were found from analysing Figure 2) to some extent. There was a rather large decrease in 2013 and 2014, but particularly over 2014. This could be because in 2014 it's likely that the subsidies to

[11] http://www.londonair.org.uk/london/asp/datasite.asp?site=CT4

producers started to have a significant effect at increasing demand for electric cars, and the advertising campaign was launched. Additionally, in 2015, there was a significant decrease in the concentrations of PM10, which could be because in 2015 the discount in the Plug-in Car Grant increased to 35%. The decrease continued, rather steadily, until 2017, which could be due to the combined effect of the policies having an ongoing and self-feeding positive effect. This suggests that the policies were one of the factors that led to the downwards trend.

Nonetheless, in 2017 there was a very substantial increase in concentrations, as they rose from 125 to 187 ug/m3, leading to the largest concentration of PM10 that there has been in the last 5 years. However, at the same time the number of electric cars was increasing at the fastest rate, as shown in Figure 2. Concentrations then decreased almost immediately to reach the lowest value only six months later.

This peak in 2017, and the other peaks that we can find in the data, could have been caused because even if the number of electric cars circulating was increasing at the fastest possible rate, it doesn't imply that the number of combustion engine cars was necessarily decreasing because of consumers switching to electric cars. This is because there are other factors that can affect, and rise, the number of combustion engine cars, such as a larger population or an increasing number of drivers. This would therefore balance out any decrease in combustion engine cars that the policies have led to, contributing towards the concentrations of PM10 not decreasing as expected. Therefore, I will look at the ratio of electric cars to combustion engine cars, to see whether the increasing number of electric cars has been matched by a decreasing number of combustion engine cars. This is what was found:

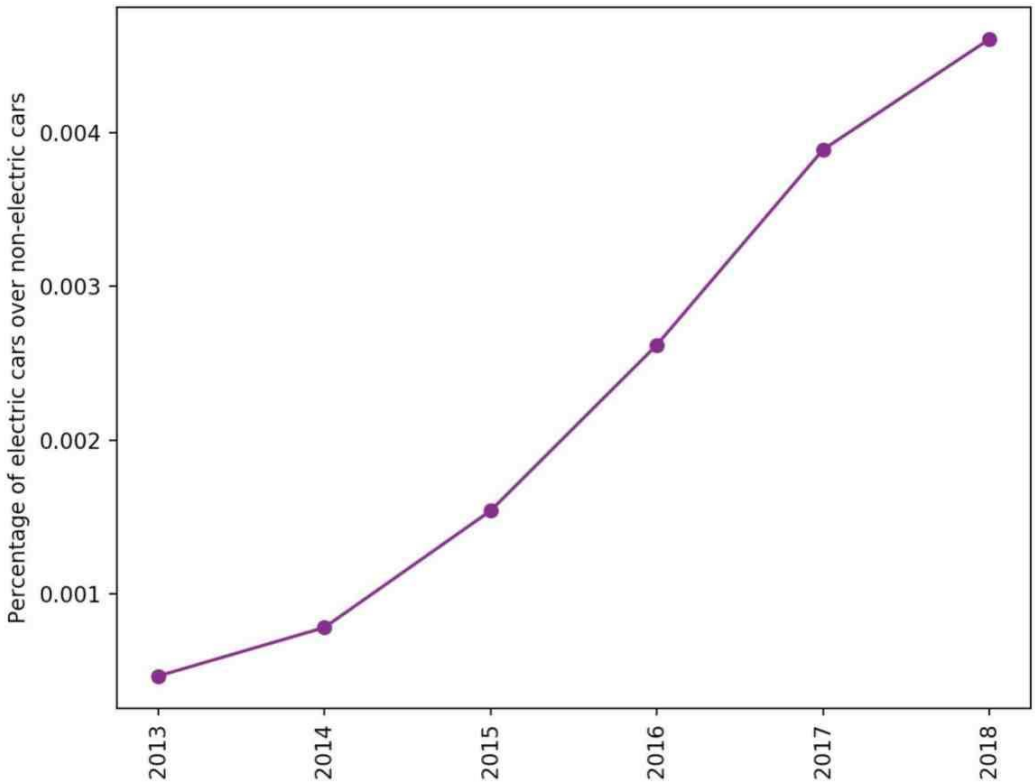

Figure 6: Graph showing the percentage of electric cars over combustion engine cars[12].

(Note that data for combustion engine cars is for central London and data for electric for the entirety of London. If they were both for central London the trend in the ratio would be equivalent, as discussed in the methodology, but the ratios would be smaller. The ratios were turned into percentages by multiplying by 100 - see appendix).

As shown in Figure 6, the ratio from electric cars to combustion engine cars has increased over the years. Therefore, since the number of electric cars is

[12] https://www.dft.gov.uk/traffic-counts/area.php?region=London

increasing, this means that the increasing ratio has been caused by either the non-electric staying the same, decreasing or increasing at a lower rate.

However, the ratio of electric cars to combustion engine cars is very small, as the largest percentage that there has been is of 0.004%. This would imply that it might be difficult for electric cars to have a significant and clearly measurable effect on air quality at this point of their market's popularization, as the number of electric cars circulating is almost insignificant compared to the rest of the cars. So although the ratio of electric to combustion engine cars will continue to increase over the years as the market for electric cars continues to expand, this means that the rising number of electric cars that the policies have led to is likely to be having a rather insignificant effect at influencing emissions of PM10 in the present in central London.

Contrastingly, the trend shown matches the findings of previous sections: there is an increase in the ratio (meaning more electric cars) from 2013 to 2014, a larger increase from 2014 to 2015, and then an even steeper increase from 2015 to 2017; this is what was found when analyzing Figure 2. However, most importantly, the ratio increased by almost half as much from 2017 to 2018 than from 2016 to 2017, meaning that there was an increase in the number of combustion engine cars because, as shown in Figure 2, the number of electric cars continued to increase at the same rate as before. Thus, this could account for the significant increase in emissions over 2017.

Additionally, whilst traffic is the largest and most significant source of PM10 in a highly transited area such as central London, there are other sources which also affect concentrations of PM10, with the most significant one being heating from houses. This could explain Figure 5's oscillations, since every year we find peaks in

winter, when heating from houses increases significantly due to the gelid winters of London, hence driving up emissions of PM10. Then, every year with the possible exception of 2018, emissions start to drop over spring and summer, at the same time that house heating starts to decrease.

However, in 2017 a £10 Pollution Charge for old and polluting cars was introduced in central London on the the 23rd of October[13]. In winter commuters would still have prefered to use their cars with the pollution charge to circulate in central London over the cold or the expensive public transport. However, in spring and summer, the policy provided owners of polluting cars with substantial incentives to commute in a more eco-friendly way, such as with a mix of both public transport and either cycling or walking. This pollution charge is estimated to have affected 10,000 combustion engine cars per day, which is very substantial and hence it's likely to be one of the main factors that led to the large decrease in concentrations of PM10 in central London over the spring and summer of 2017, together with less heating from houses.

Besides this, on the 1st of July 2013 the Ultra Low Emission Discount scheme went into effect[14]. This ordered a 100% discount of the Congestion Charge (an £11.50 standard charge per vehicle to enter central London) for the greenest cars. This scheme increased the amount of electric cars that circulated in central London, since it provided electric car owners with incentives to circulate in central London more often due to the discount. Hence it's also likely to have had an effect at

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13 https://www.theguardian.com/environment/2017/feb/2017london-to-introduce-vehicle-pollution-charge-in-october-says-mayor-sadiq-khan

14 https://tfl.gov.uk/info-for/media/press-releases/2013/april/ultra-low-emission-discount-to-make-congestion-charge-scheme-greener

reducing the emissions of PM10 by increasing the ratio from the electric cars to the rest of cars in the central areas of London. The effect of this is likely to have been larger than the government policies, as it targets central London directly whilst government policies target the whole of UK.

5. Conclusion

This research has found that government interventions in the electric car market have led to a significant increase in the demand for electric cars, through the use of three main policies that have influenced consumer preferences, led to technological advances and increased production of electric cars. The growth of the electric car market is likely to continue into the future. The increasing demand for electric cars due to the policies is thus one of the factors that has contributed towards the downwards trend of PM10 in central London. Consequently, to some extent, it has caused the negative externality of consumption of combustion engine cars to be reduced, improving central London's air quality.

However, it has also been found that although the number of electric cars is increasing, it still remains a very small proportion of the total number of cars in circulation. This implies that the rising number of electric cars has not yet had a very significant effect on the emissions of PM10, due to the still large number of combustion engine cars as compared to electric cars. Therefore, this investigation has answered the research question successfully, as the UK Government's interventions in the electric car market have led to a decrease in PM10 concentrations in central London to a rather small, and maybe insignificant, extent.

On the other hand, the effects of the policies may become significant in the future as the ratio from electric cars to combustion engine cars continues to increase because of the policies; although the increase might happen over a limited time period, and that at one point the line will flatten out reaching an asymptote. This could be looked at in the future when more data is available.

Thus, other factors that have been discussed, heating from houses and policies introduced by the local authorities, have likely influenced concentrations of PM10 in central London more substantially. Nonetheless, the question of how much it was the increase in electric cars what contributed to the fall in pm10 particulates and not something else remains unanswered. Moreover the government policies and London's authorities' policies could have combined to have the effect, which would mean that the government policies were just insufficient on their on. However, the answer to this remains unknown, hence it could be investigated in further research.

There were some limitations when carrying out this research, mainly when obtaining data. Due to the data for electric cars in central London in particular being private, data for the whole of London had to be used. As discussed, the trends would be mostly equivalent. However, if the data were for central London only, the trend would be more accurate, and hence more appropriate for contrasting it with emissions of PM10 in central London. Moreover, the negative externality of combustion engine cars doesn't only arise because they produce PM10, but also because of other polluting and harmful gases such as carbon dioxide or nitrogen oxides. Therefore, in further research these would also be taken into account.

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Appendix

Data on electric cars:

	Electric cars in London	Combustion engine cars in central London	Ratio of electric to combustion engine cars x 100
2013	1150	248,103	0.0004635172
2014	2025	259,843	0.0007793167
2015	4150	269,629	0.0015391519
2016	6875	262,589	0.0026181599
2017	10075	259,049	0.0038892256
2018	12000	260,409	0.0046081357

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EE/RPPF

For first assessment in 2018

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Candidate personal code

Extended essay - Reflections on planning and progress form

Candidate: *This form is to be completed by the candidate during the course and completion of their EE. This document records reflections on your planning and progress, and the nature of your discussions with your supervisor. You must undertake three formal reflection sessions with your supervisor: The first formal reflection session should focus on your initial ideas and how you plan to undertake your research; the interim reflection session is once a significant amount of your research has been completed, and the final session will be in the form of a viva voce once you have completed and handed in your EE. This document acts as a record in supporting the authenticity of your work. The three reflections combined must amount to no more than 500 words.*

The completion of this form is a mandatory requirement of the EE for first assessment May 2018. It must be submitted together with the completed EE for assessment under Criterion E.

Supervisor: *You must have three reflection sessions with each candidate, one early on in the process, an interim meeting and then the final viva voce. Other check-in sessions are permitted but do not need to be recorded on this sheet. After each reflection session candidates must record their reflections and as the supervisor you must sign and date this form.*

First reflection session

Candidate comments:

I chose to look at policies aimed at introducing electric cars into the market to reduce CO2 emissions. I will focus on London because it was important to focus on just one city, as there will be less factors affecting CO2 emissions other than the increasing number of electric cars circulating. Preliminary research shows the Government has provided purchase incentives and subsidies.
To determine how effective the policies have been, I will gather data on electric cars circulating in London, to contrast it with data on CO2 emissions and look for trends. I will also investigate other factors, like the ratio of electric to non-electric cars to see if consumers are actually switching to electric.

Date: 10/9/2018

Supervisor initials:

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Interim reflection

Candidate comments:

I decided to switch from CO2 emissions to PM10 emissions because they are more harmful, therefore it's more important that these are reduced. The main public measuring stations for PM10 are in central London. It was an adequate area for my research, hence I decided to change the focus of the essay to central London. However, I was only able to find data for electric cars for London as a whole, though I concluded the trends would be equivalent.
Discussing with my supervisor we have seen that there's a main issue with my work so far: my economical theory and my data are in separate sections, so I'm not using theory to evaluate the policies with the data; my data analysis is too descriptive and repetitive. The essay will need restructuring to link everything together and add evaluation. Moreover, I will need to further investigate whether data on cars is correlated with PM10 concentrations by linking in other factors, as there are large variations in the PM10 data.

Date: 01/11/2018

Supervisor initials: _____

Final reflection - Viva voce

Candidate comments:

I learned that the policies regarding electric cars had a smaller effect than I initially expected in reducing PM10 emissions because of the really small ratio of electric to non-electric cars. Nonetheless, I think that over time the effect will become more noticeable.
Looking at relating the economic theory to the data helped me better understand its limitations, as it suggested a more positive impact than what I observed. When researching and gathering data on emissions I found a large database, so I had to employ my programming skills to obtain suitable data for investigation that would allow me to do effective analysis. I also developed research and organisation skills as I had to structure my time appropriately to ensure I was able to complete the essay in enough depth within the time and word limit.
In hindsight, I would have given myself more time to obtain data for electric cars, since although it is private for central London, it might be possible to contact the Council and be granted access. This would have made comparisons more meaningful, as central London is the area I was focusing on, although I was still able to reach a conclusion. I also could have looked at more emissions than just PM10, to see if the effects on PM10 were consistent.

Date: 14/12/2018

Supervisor initial

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