HM Revenue & Customs

HM Treasury

Analysis of the dynamic effects of fuel duty reductions

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Executive Summary

- Since 2010 the Government has committed to increase the transparency and sophistication of its modelling of the effects of policies. It has published policy costings and distributional impacts for the first time, and in recent Budgets and Autumn Statements has continued to improve the modelling underpinning each.
- As part of this, HMRC has developed a Computable General Equilibrium (CGE) model, capable of modelling the dynamic macroeconomic effects, and subsequent Exchequer revenue effects of a major policy change.
- The model has been peer-reviewed by leading academics in the relevant field, who found that '*The basic design of the HMRC model for the UK economy meets at large the key requirements for state-of-the-art applied tax policy analysis'.*
- In December 2013 HMRC published an "Analysis of the dynamic effects of Corporation Tax", allowing (for the first time) the Government to publish retrospective policy analysis of the dynamic effects of government policy, based primarily on the CGE model.
- This report shows the results of applying the CGE model to the real terms fuel duty reductions announced since 2010. Fuel duty in real terms is forecast to fall over this Parliament by 13 per cent. Without policy changes, rates would have increased by 7 per cent. The result after these changes is that fuel duty is around 20 per cent lower than previously planned.
- These reductions in the real rate of fuel duty have come in the context of unprecedented economic circumstances. The economy was recovering from the deepest recession since the war. Average oil prices increased from $80 in 2010 to $110 in 2011, and have remained elevated; and because of the financial crisis earnings growth was below inflation from 2008.
- The modelling suggests that these reductions in duty will increase GDP by between 0.3 and 0.5 per cent in the long-term. The modelling shows increased

profits, wages and consumption all add to higher tax revenues. As a result, the cost of the policy falls by between 37 and 56 per cent in the long-term.

- As a tax which falls on businesses, as well as households, and was set at a high rate in 2010, the model shows fuel duty to be one of the most distortive taxes, with a reduction in rates generating significant dynamic effects. Important factors in determining the size of the GDP effect include the proportion of tax falling on business inputs and the initial tax rate, which in 2010 was particularly high. Because of this the first fuel duty reduction has the largest effect, with a diminishing GDP impact as the tax rate falls further for subsequent cuts.
- The CGE model is subject to some uncertainty. This is principally around the parameters included, for which sensitivity analysis is carried out. These parameters are consistent with academic literature in the area. Economic uncertainty, not captured by the model, could also impact on the results in the short-term. Some factors are not captured by the CGE model. These include externalities such as congestion, although is not expected that these impacts would have a material effect on the main findings in this report. Some productivity effects associated with higher investment are also not captured by the model.
- The CGE model is not a short-term forecasting model. Its strength is in modelling the long-term economic effects of policies rather than forecasting short-term economic fluctuations.

Chapter 1 - Introduction

1.1 Since 2010 the Government has committed to increase the transparency and sophistication of its modelling of the effects of policies. It has published policy costings and distributional impacts for the first time and over recent Budgets and Autumn Statements has continued to improve the modelling underpinning each. Publishing details of HMRC's Computable General Equilibrium (CGE) is another step in this direction.[1]

1.2 In December 2013 HMRC published an "Analysis of the dynamic effects of Corporation Tax", allowing (for the first time) the Government to publish retrospective policy analysis of the dynamic effects of government policy, based primarily on the CGE model.

1.3 CGE models have been used since the early 1970s to analyse the economic effects of changes in taxation.[2] Governments and institutions such as the World Bank, OECD and IMF, use CGE models in some form.

1.4 HMRC's CGE model contains a detailed representation of the UK tax system. It is capable of modelling the dynamic macroeconomic effects, and subsequent Exchequer revenue effects, of major policy changes. The model has been peer-reviewed by leading academics in the relevant field. The peer review concluded that *'CGE models are obviously a prime candidate for the quantitative impact assessment of tax policy reforms. They provide a comprehensive analytical framework to capture direct and indirect tax interaction and revenue recycling effects',* and that *'The basic design of the HMRC model for the UK economy meets at large the key requirements for state-of-the-art applied tax policy analysis.'*[3]

1.5 This report shows the results of applying the CGE model to the fuel duty reductions announced since 2010.

[1] https://www.gov.uk/government/publications/computable-general-equilibrium-cge-modelling
[2] See for example Shoven, J.B., & Whalley, J. (1972) *"A General Equilibrium Calculation of the Effects of Differential Taxation of Income from Capital in the U.S.",* Journal of Public Economics.
[3] https://www.gov.uk/government/publications/computable-general-equilibrium-cge-modelling

1.6 Fuel duty raises approximately £27bn per annum and is the fifth largest source of government revenue. Fuel duty plays an important role in supporting sustainable public finances and internalising the externalities associated with road transport, in particular greenhouse gas emissions.

1.7 Budgets 2009 and 2010 announced the introduction of a fuel escalator whereby fuel duty would increase by 1 pence per litre above inflation each year from 2010 to 2014. At Budget 2011, to support households and business with the high cost of fuel, the fuel duty escalator was abolished and replaced with a fair fuel stabiliser; and the rate of duty was cut by 1 pence per litre. Since 2011, the annual inflation increase in fuel duty has been cancelled, meaning that there have been a series of real-terms reductions in the rate of fuel duty.

1.8 Fuel duty will be frozen in nominal terms for the remainder of this Parliament. Fuel duty in real terms is forecast to fall over this Parliament by 13 per cent. Had the fuel duty escalator been implemented, rates would have increased by 7 per cent.

1.9 This is around a 20 per cent cumulative reduction compared to what would have otherwise happened. It has come in the context of pressures on households and businesses at a time when:

- Average oil prices increased from $80 in 2010 to $110 in 2011, and have remained elevated. As a result pump prices increased to record highs. The price of petrol increased from approximately 90 pence per litre in late 2008 to over 140 pence per litre in 2012, and have since broadly remained over 130 pence per litre.
- The inflation rate was above target, peaking at 5.2 per cent in September 2011.
- Earnings growth has been subdued as a result of the financial crisis. Between 2008 and 2013, annualised earnings were below inflation. The OBR forecast earnings to grow more rapidly than inflation from this year.

1.10 As well as affecting motorists, fuel is an important input for many businesses. Therefore, in addition to supporting motorists with the cost of living, freezing and cutting fuel duty reduces costs to business, supporting overall economic activity.

1.11 Modelling policy changes in the CGE model is a complex activity, and providing robust analysis requires an in-depth understanding of how the model works. It is not possible to simply run the CGE model for each and every policy option. CGE analysis is best suited to policies with clear dynamic effects. The fuel duty reductions are therefore a good modelling choice. This modelling gives a new insight into the long-term effects of this policy on the economy and public finances.

1.12 The remainder of this report is set out as follows:

- Chapter 2 sets outs the direct effects of fuel duty and discusses the methodology used for government costings of the fuel duty reductions;
- Chapter 3 describes the macroeconomic and fiscal effects of the fuel duty reduction, as suggested by economic theory and supported in academic literature;
- Chapter 4 shows the CGE modelling results on the effect of a fuel duty reduction on the economy and public finances;
- Chapter 5 presents conclusions.

Chapter 2 – Direct effects of a reduction in fuel duty

2.1 This chapter sets out the context in which the fuel duty rates reduction has taken place. It discusses the methodology, certified by the Office for Budget Responsibility (OBR), used to cost the direct effects of a reduction. These costings are an important input into the CGE modelling.

Fuel duty rates and receipts

2.2 Fuel duty is an important revenue stream for the government, being the fifth highest yielding tax.[4] Receipts for 2012-13 were £26.6 billion. The tax is payable on every litre of taxable fuel that is made available for use in the UK, and is typically charged at the point that fuel leaves the refinery. While the tax applies to a range of fuels, petrol and diesel make up over 95 per cent of all receipts.

2.3 Duty on fuels is regulated by the EU Energy products directive, which also sets minimum rates. In general, rates in the UK are well above the EU minima. Box 2.1 discusses the relationship between pump prices and oil prices.

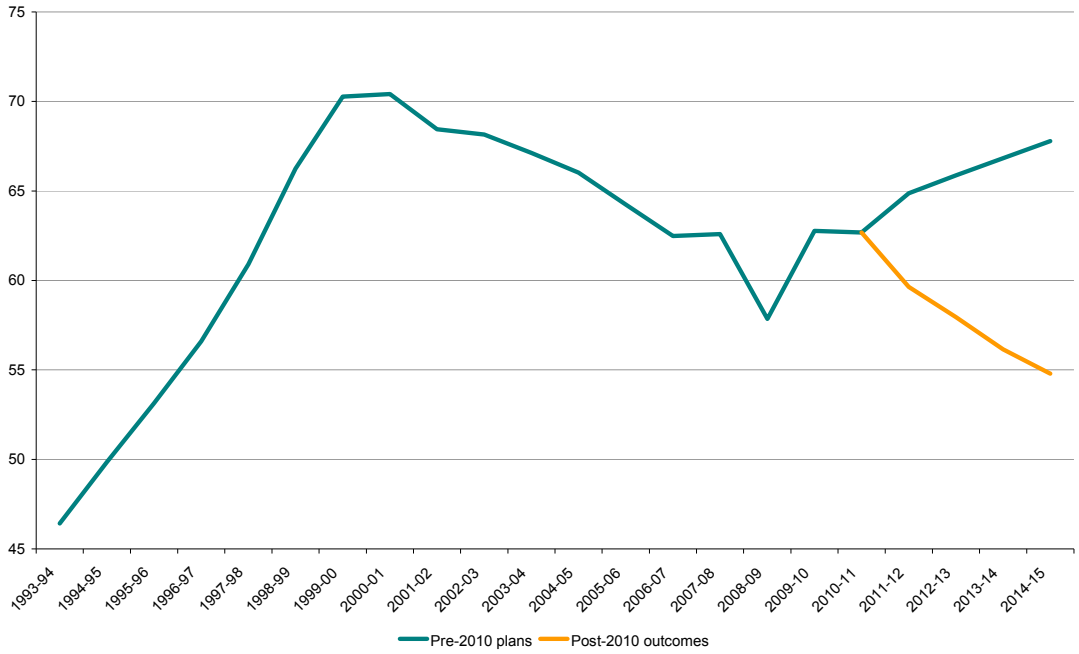
2.4 Chart 2.1 shows the fuel duty rate on petrol from 1993-94 to 2014-15 in 2012-13 prices. The main rates for diesel and petrol have been the same since April 2008.

2.5 The fuel duty escalator was introduced in April 2010, whereby rates were scheduled to increase each year by inflation (the Retail Price Index; RPI) plus one pence per litre. This was due to continue up to and including April 2014.

2.6 At Budget 2011 the Government postponed the scheduled rise in line with inflation, and instead cut rates by one pence per litre. Fuel duty rates have remained frozen at this level ever since, and will remain so for the remainder of this Parliament. This will constitute the longest freeze in fuel duty rates for over twenty years.

[4] OBR Economic and Fiscal Outlook 2014, Supplementary Fiscal Tables, Table 2.8

Chart 2.1: Real terms petrol duty rates 1993-94 to 2014-15, pence per litre



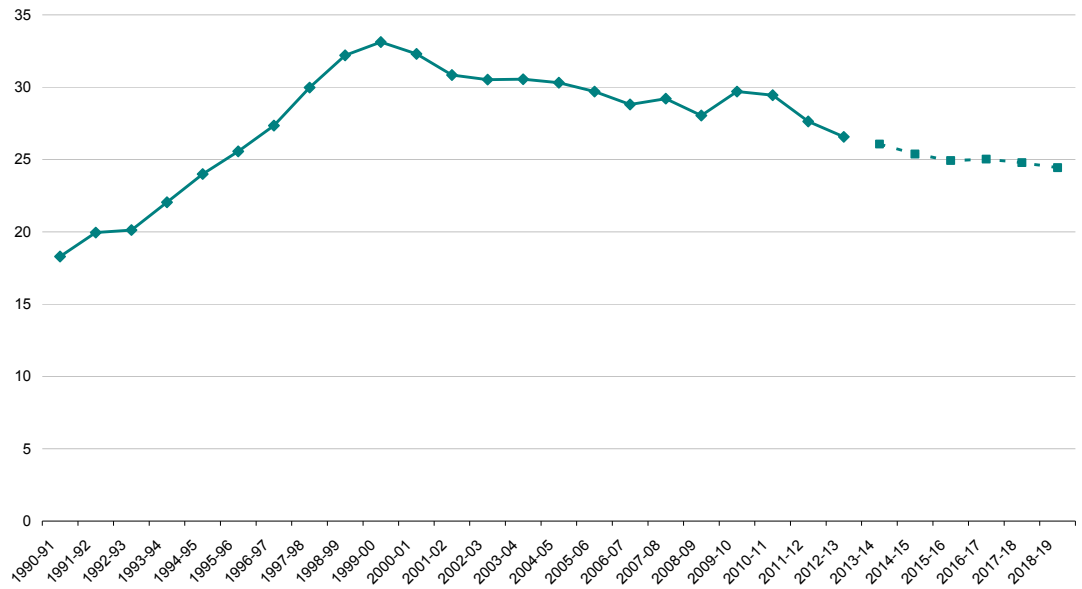
Source: HMRC, 2012-13 prices.

2.7 Chart 2.2 shows UK fuel duty receipts in real terms, from 1990-91 to 2012-13, and future receipts from 2013-14 to 2018-19, as projected by the OBR in their Economic and Fiscal Outlook at Budget 2014. Over this period there has been a general increase in the fuel-efficiency of vehicles for sale and in the stock of vehicles on the road. Absent other factors, this would lead to declining fuel duty receipts.

2.8 There was a steep rise in receipts in the 1990s, corresponding with the fuel duty rate escalator active at that time. The overall quantity of taxable fuel released for consumption declined during this period.

2.9 Annual receipts flatten out in the following decade and decline slowly. This is a result of the freeze on duty rates and the quantity of fuels released remaining relatively stable. The fluctuations in receipts from 2008-09 onwards relates to the changes in fuel duty rates described above. Future fuel duty receipts are forecast to remain relatively stable in real terms.

Chart 2.2: Real fuel duty tax receipts (actual and projected), £ billion (2012-13 prices)



Sources: HMRC; OBR

2.10 The overall trend in fuel duty receipts can mask compositional changes. For example, since 1999-00 petrol receipts have been declining in nominal terms, whilst nominal diesel receipts have risen. This is linked to a gradual change in consumer behaviour, as road users switch from vehicles with petrol engines to those with diesel ones.

The direct effects of a reduction in fuel duty

2.11 The government's estimates of the Exchequer effects of fuel duty reductions are based on forecasts of the amount of taxable fuel made available for use in the UK. They assume a behavioural response that adjusts demand for fuel as a result of a change in price. This behavioural response is captured by an elasticity between the price of fuel and the amount consumed. A reduction in the fuel duty rate will increase demand for fuel, as vehicle owners will use more of it. This has a positive impact on receipts. Therefore the Exchequer cost of a reduction in the rate of fuel duty is less than if there had been no behavioural response.

2.12 HMRC estimate that a one percentage point decrease in the fuel duty rate would lead to a direct increase in the demand for fuels of 0.07 per cent in the short run, and 0.13 per cent in the medium run. As the behavioural effects upon petrol and diesel are expected to be slightly different, these are split into separate elasticities for the two fuels. This is done using two key assumptions; (a) that the usage of diesel is less elastic to a change in price, as it is more frequently used in business where the ability to reduce journeys is lower, and (b) the percentage of miles driven by diesel vehicles.

2.13 The methodology assumes that 100 per cent of the tax is passed through from the registered traders, who collect the tax, to the final users (i.e. vehicle owners at the pump) who ultimately pay the tax.

2.14 As with all tax changes, it is the OBR's responsibility to certify formal costings of the direct effects of fuel duty reductions for inclusion in their forecasts. These direct effects are accompanied by behavioural effects where appropriate, and the OBR are responsible for deciding whether to adjust their economic forecast for the indirect effects of policies[5]. In the case of fuel duty, the OBR chose to reduce its short-term inflation forecast[6].

2.15 The CGE model can be used to estimate the wider dynamic macroeconomic effects of individual policies. The next chapter considers such effects resulting from the fuel duty rates reduction.

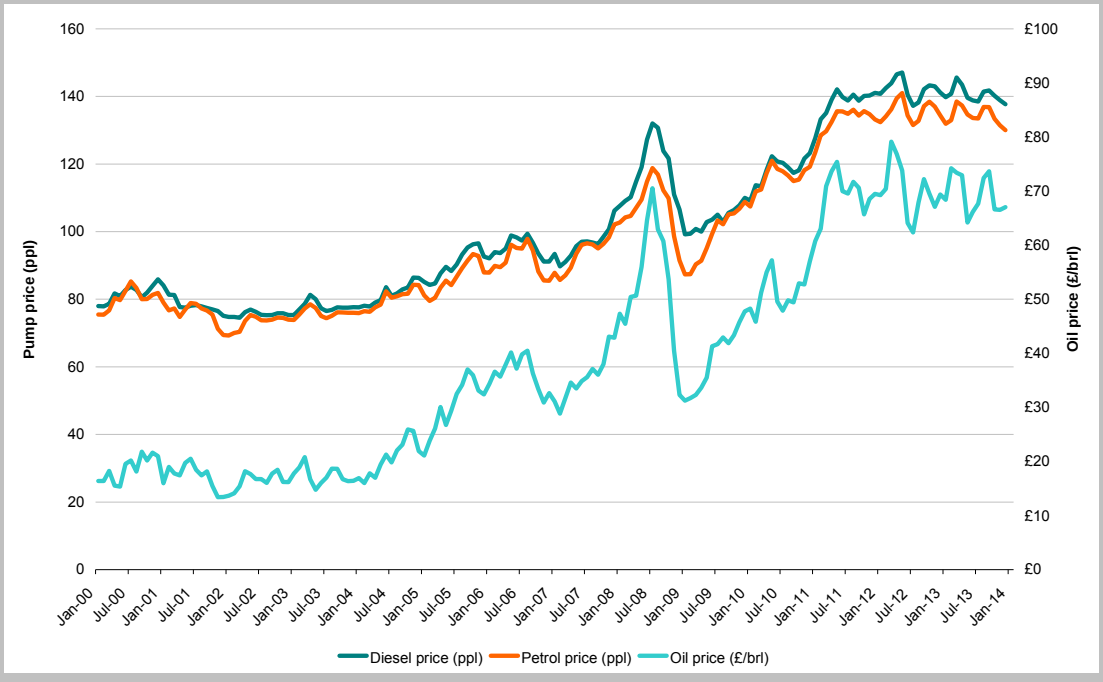
[5] For more information on how the OBR incorporates the indirect effects of policy into their forecasts see OBR, 2014 *"Briefing paper No.6: Policy costings and our forecast"*: http://budgetresponsibility.org.uk/category/publications/briefing-papers/

[6] http://budgetresponsibility.org.uk/wordpress/docs/economic_and_fiscal_outlook_23032011.pdf

Box 2.1: Fuel duty and oil prices

1. Changes in oil prices affect the pump prices of diesel and petrol.
2. The *Fair Fuel Stabiliser*, announced at Budget 2011, stipulates that as long as the price of oil exceeds a particular level, rates of fuel duty will not be increased by more than RPI.
3. Chart 2.3 shows the relationship between pump prices and oil prices from 2000 to 2014. There is not a clear relationship with fuel duty rates.
4. Recent analysis during a market investigation by the Office of Fair Trading[1] about how much of a given rise or fall in the oil price is passed-through to the pump price did not find evidence for the presence of asymmetric pass-through to the final pump prices of diesel and petrol. This analysis found that it can take up to 5 weeks for full pass-through to occur.

Chart 2.3: Pump prices and oil prices 2000 – 2014



Sources: Bloomberg; DECC

[1] OFT (2013) Call for information on the UK petrol and diesel fuels sector, Annex E: http://www.oft.gov.uk/OFTwork/markets-work/othermarketswork/road-fuel-CFI/

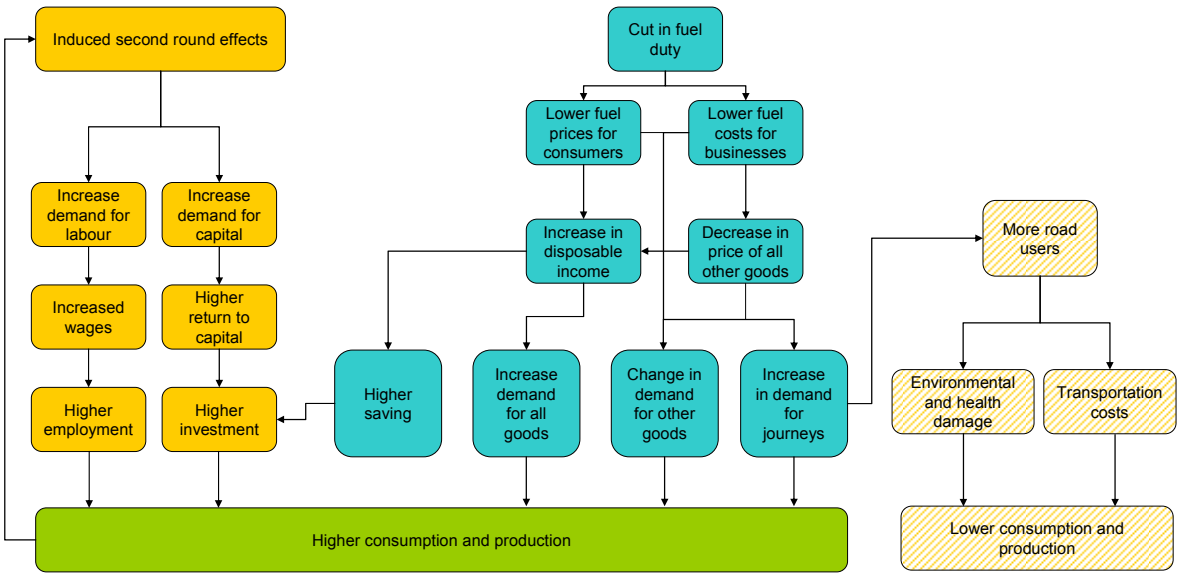
Chapter 3 – Theory and supporting literature on the dynamic macroeconomic effects of fuel duty reductions

3.1 This Chapter looks at the theory behind how a reduction in the fuel duty might affect real economic activity and GDP, and subsequently feed back into tax receipts. It also considers the academic evidence supporting this theory.

Theory: Macroeconomic transmission mechanism

3.2 Chart 3.1 below shows the alternative channels through which a fuel duty reduction could affect GDP. The blue and orange boxes identify the effects that are captured by the CGE model such as price, income, consumption and investment changes. The striped orange boxes represent effects that are not captured by the CGE model such as externalities resulting from greater road use. These externalities could dampen the effect of the fuel duty cut on GDP.

Chart 3.1: Channels through with a reduction in fuel duty affects GDP



3.3 The discussion below sets out how a cut in fuel duty affects the economy. Note that all these mechanisms happen simultaneously in the economy, the order below is just to help with clarity.

Increase demand for road transport (own-price effect)

3.4 For consumers and businesses fuel is cheaper because of the lower rate of duty, leading to increased demand for petrol and diesel. This follows through to a greater use of road transport in the economy, with frequency of trips and miles driven expected to increase. For example this channel may contribute to greater employment in the haulage industry.

Increase demand for other goods and services (cross-price effect)

3.5 Demand for goods and services that are complements to fuel and road transport may be expected to increase. For instance businesses may buy more vehicles and consumers may purchase more car maintenance. Substitutes to fuel and road transport may experience a decrease in their demand, for instance both consumers and business may use less rail transport.

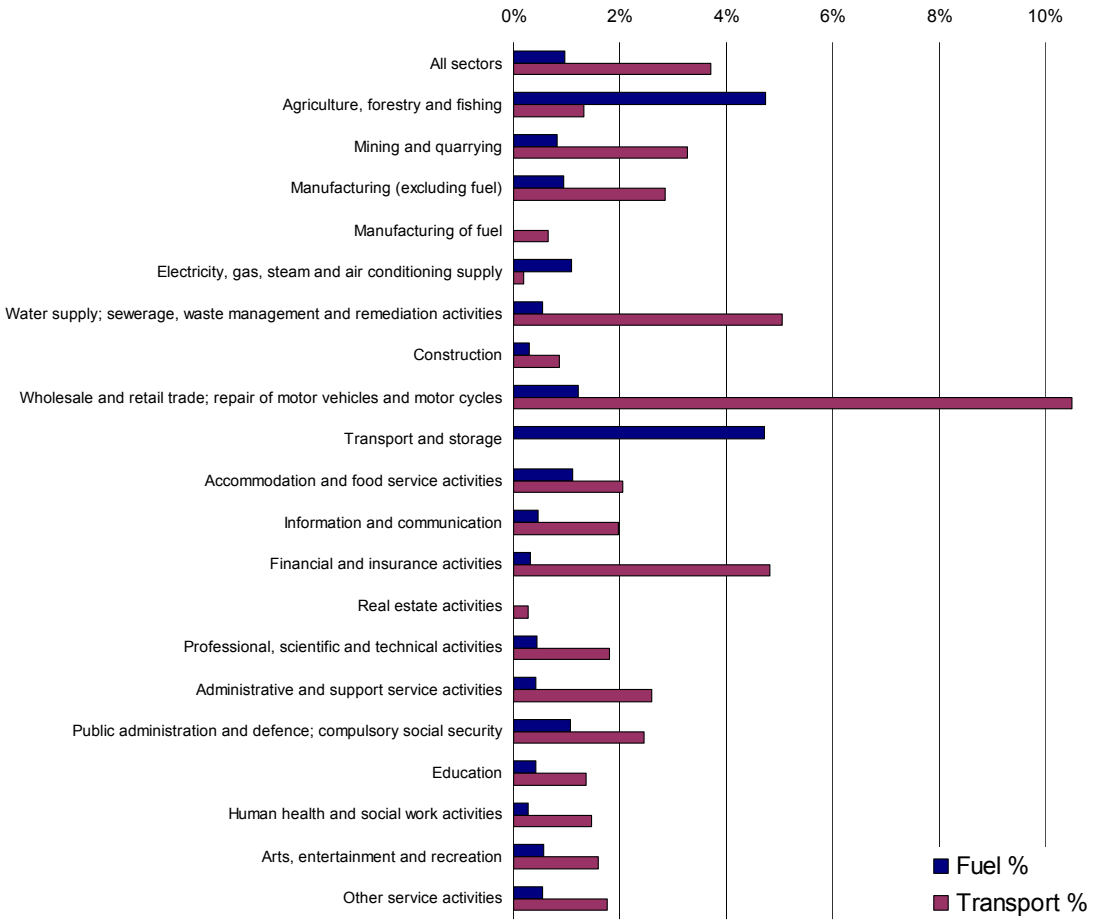
Increase demand for all goods and services (income effect)

3.6 Cheaper fuel benefits the budgets of households and businesses alike as the same quantity of fuel can be purchased for less money. Households may decide to spend additional money on other goods and services in the economy. Businesses may also demand other goods and services in order to increase production to take advantage of cheaper fuel.

Increase demand for all goods and services (production and consumption distortions)

3.7 Following a cut in fuel duty, firms that use fuel as a key input into production, such as the transport sector, and firms that make significant use of the transport sector, will experience a decrease in their production costs. If firms pass on some of these savings, then lower costs will cascade throughout the economy resulting in cheaper prices for goods and services, for both consumers and firms, which in turn will stimulate output. This is a key mechanism through which fuel duty cuts reduce the distortions across the supply chain and consumer choices. As businesses make use of fuel and transport in different proportions then some sectors will benefit disproportionally from the cut, altering the structure of the economy towards a more economically efficient allocation of resources.

Chart 3.2: Fuel and transport use as a proportion of total inputs (capital, labour and intermediate goods) by sector



Source: ONS, Supply and Use tables, 2012 edition

3.8 Chart 3.2 above shows each sector's fuel and transport expenditure as a proportion of spending on capital, labour and intermediate goods; on average 1 per cent of all sectors spending on all inputs goes on fuel. The transport and storage sector spends 4.7 per cent on fuel. Furthermore, 3.7 per cent of all spending on inputs goes towards transport goods. In particular the retail sector spends over 10 per cent of inputs cost on the transport sector.

Factor demand

3.9 Aggregate demand in the economy will increase following fuel duty cuts through all the channels described above that act to increase real income. To meet this additional demand firms will need to hire more workers and rent more capital. To

do so firms may have to increase wages and payments to capital owners to induce higher labour supply and investment in the economy.

Investment

3.10 Higher factor demand from firms will stimulate investment in capital goods to meet additional consumer demand. Increased investment affects GDP through its short-run effect on the level of demand in the economy and through its long-run effect on how much output the economy can supply. A larger capital stock enables the economy to produce more output in the future, although it may take time for the effects of this larger capital stock to fully feed into a higher level of GDP.

Receipts

3.11 The macroeconomic effects set out above are likely to have a positive effect on receipts. Stronger growth will eventually generate tax revenues that recoup a proportion of the revenue lost directly from a real cut in the fuel duty.

3.12 Increases in wages and higher returns on capital will lead to increased Income tax and National Insurance contributions and to additional Corporation Tax receipts. Higher consumption will generate extra Value Added Tax (VAT) and excise duty receipts.

Supporting Literature

Economic Theory

3.13 There are a range of factors that have been identified from economic theory as being important in determining the economic impact of a change in taxation, and therefore the magnitude of the effects described above. The main factors are:

- The initial tax rate
- The proportion of the tax falling on business inputs
- The relevant price, cross-price and income elasticities
- Labour supply effects
- The cost of externalities generated by the taxed commodity.

3.14 These are discussed in more detail below in the context of fuel duty.

Initial tax rate

3.15 The economic impact of a tax tends to increase disproportionately with the tax rate, as consumers and producers try harder to substitute away from the highly taxed good, causing a larger reduction in output. High pre-existing taxes in other parts of the economy will also magnify the impact of taxes imposed elsewhere in the economy. Hence, a reduction from a relatively high tax rate would be expected to lead to a larger increase in economic activity than an equivalent reduction from a lower initial tax rate.

3.16 For that reason a smaller revenue loss would be expected from cutting a tax from a relatively high rate, as the larger increase in economic activity will expand the size of that and other related tax bases and thereby offset a greater proportion of the static cost.

3.17 The initial high rate of fuel duty in 2010 means that the cuts to fuel duty would be expected to have a larger positive effect on economic activity than other alternatives. This effect is likely to be amplified by the uneven use of road fuel across sectors of the economy. As the effective rate of duty gets lower over time the effect of fuel duty reductions on GDP will reduce, meaning that the last reduction modelled by the CGE model shows a proportionally smaller impact on

GDP than the first. By the end of 2014-15, after this government's changes, the real level of fuel duty will be at its lowest level since 1995-96..

Proportion of tax on a business input

3.18 As discussed above, fuel duty is a tax on a business input. Such taxes tend to be more distortive than other taxes in the absence of externalities. This is because an input tax will reduce the efficiency of production[7] as well as raise the relative price of goods and services that require that input, making consumers worse off.

3.19 Around 50 per cent of road fuel is used as an intermediate input by businesses[8]. While this is lower than the proportion of labour and capital used by businesses, Chart 3.2 shows that the use of road fuel is heavily skewed towards certain sectors, such as transport. It is therefore expected that the impact on relative prices and negative impact on consumption would be higher for changes in the price of fuel than for inputs used more uniformly across the economy.

Price and income elasticities

3.20 Economic theory suggests that taxing goods that are less price-elastic will have smaller economic effects, since demand will fall by less for a given amount of revenue. Conversely, we would expect tax cuts on more price-elastic goods to generate larger economic benefits from the higher increase in demand, which should in turn generate some additional revenue to offset the static cost of the tax cut.

3.21 The evidence on the price-elasticity of demand for road fuels is presented in Table 3.1, and shows that fuel is relatively price-inelastic. On its own this would suggest that cutting fuel duty will have a relatively small economic impact, however, this depends on whether this effect will dominate the other channels through which a tax can affect the economy.

[7] Diamond, P. A., & Mirrlees, J. A. (1971) *"Optimal taxation and public production I: Production efficiency"*, The American Economic Review, 8-27.
[8] ONS Supply and Use tables, 2012 Edition

Table 3.1: Price elasticity of demand for fuel

Source	Description	Price Elasticity
HMRC indirect taxes forecasting model	These elasticities underlie the OBR's forecast of fuel duty receipts.	-0.07 in the short-term -0.13 in the medium-term
Dahl (2012)[9]	A meta study examining the elasticities for petrol and diesel for various countries. [10]	-0.11 to -0.33 for petrol -0.13 to -0.38 for diesel
Brons et al (2008)[11]	A meta study exploring both short-run and long-run elasticities.	-0.34 in the short-term -0.84 in the long-term
Parry and Small (2005)[12]	A study exploring the ideal fuel tax for the UK and the US.	-0.55 with a range of -0.3 to -0.9

3.22 As set out in Chapter 2, the government's estimation of the direct Exchequer effect of changes in fuel duty includes a simple behavioural effect based on a price elasticity of demand for fuel. These are taken directly from the underlying the OBR forecast. These price elasticities are -0.07 in the short run and -0.13 in the medium-term. The price elasticities used in HMRC's indirect taxes forecasting model are not directly comparable with the elasticities in the CGE model. The former elasticity governs the change in demand following the reduction in fuel price assuming that everything else is constant in the economy. However, households' income, firms' output and price of other goods will also change following the change in fuel price, and these effects will in turn change fuel demand. The CGE elasticity reflects the change in fuel demand after all the second round

[9] Dahl, C. A. (2012) *"Measuring global gasoline and diesel price and income elasticities"*, Energy Policy 41, 2-13.
[10] The estimates in this analysis are from 'static' models; Dahl (2012) notes that static models tend to produce elasticity estimates that are between the short-run and long-run estimates that are produced by dynamic models.
[11] Brons, M., Nijkamp, P., Pels, E., & Rietveld, P. (2008) *"A meta-analysis of the price of elasticity of gasoline demand. A SUR approach"*, Energy Economics 30 (5), 2105-2122.
[12] Parry, I. & Small, K. (2005) *"Does Britain or the United States have the right gasoline tax?"*, American Economic Review 95(4), 1276–1289.

macroeconomic indirect effects have been captured and is likely to be higher than the partial elasticity. The CGE price elasticity of demand for fuel is -0.35 rising to -0.43 after 20 years.

3.23 Cross-price elasticities are also important in determining the economic effect of a cut in fuel duty. Demand for other goods and services will change following the cut depending on whether they are complements or substitutes for fuel. The size of the cross-price elasticities could significantly affect the magnitude of impacts across sectors and result in a different distribution of tax revenues[13].

Labour supply effects

3.24 Economic theory suggests that goods which are complements to leisure should be taxed more heavily to reduce labour market disincentives[14]. A cut in fuel duty could result in fewer hours being worked as leisure trips become cheaper. On the other hand cheaper fuel reduces the cost of travelling to work, which could increase labour supply.

Externalities

3.25 Goods which when consumed impose costs on others ("negative externalities") are over-consumed because households and firms fail to take these effects fully into account, since these costs are not reflected in the market price. Congestion and air pollution as a result of vehicle use are both examples of negative externalities. Taxes can be used to correct for these externalities by increasing the market price to reflect the cost of the damage caused by them.

3.26 While most externalities have social welfare effects, such as air and noise pollution, congestion could have effects on GDP as well as wider social welfare effects. Higher congestion could increase the cost of transportation (for example, haulage) which can result in lower output from firms. IFS (2012)[15], using the DFT (2010)[16] National Transport Model, show that on the most congested roads the

[13] Goulder, L. H., & Williams III, R. C. (2003) *"The Substantial Bias from Ignoring General Equilibrium Effects in Estimating Excess Burden, and a Practical Solution"*, Journal of Political Economy 111(4), 898-927.
[14] Corlett, W. J., & Hague, D.C. (1953) *"Complementarity and the Excess Burden of Taxation"*, Review of Economic Studies 21(1), 21-30.
[15] http://www.ifs.org.uk/publications/6175
[16] DfT (2010). Transport Analysis Guidance (TAG) Unit 3.9.5: MSA Major Schemes Appraisal Road Decongestion Benefits

marginal externality can be up to £2.50 per kilometre, although some of these costs are non-economic. There are studies that consider the effect of fuel duties on externalities[17]. The CGE modelling presented below is not intended to capture the impact of a reduction in fuel duty through externalities. Although estimating the effect of fuel duty on journeys is relatively uncomplicated, it is more complex to identify how many of the additional journeys are on congested roads and to calculate the resulting GDP impact. It is not expected that the impacts on congestion would have a material effect on the main findings in this report.

GDP and receipts impacts

3.27 There have been relatively few studies evaluating the impact of fuel duty changes on consumption, investment or receipts.

3.28 NIESR (2012)[18] use an econometric model to estimate the impact of a 3 pence cut in fuel duty, amongst other scenarios, and find that it would increase GDP by 0.11 per cent within a year. They find the rate cut would worsen the fiscal balance due to a loss in tax revenue, but by less than 0.2 per cent of GDP.

3.29 Unlike the CGE model, NIESR's results do not extend beyond one year ahead and reflect the short-term impact of a fuel duty change given the cyclical position of the UK economy. The CGE model, on the other hand, does not take account of exogenous short-term shocks and fluctuations but is set up to model the transition of the economy to a new long run equilibrium following a policy change.

[17] Parry, Ian W. H., and Kenneth A. Small. 2005. "Does Britain or the United States Have the Right Gasoline Tax?" American Economic Review, 95(4): 1276-1289.
[18] Delannoy, A., Holland D., & Liadze, I. (2012) *"The Impact of Fuel Duty on the Macro-Economy for FairFuelUK".*

Chapter 4 – Modelling fuel duty rate reductions using HMRC's CGE Model

4.1 This Chapter explains how the CGE model has been used to simulate the effects of the reductions in the rate of fuel duty. It summarises the results in terms of increased economic activity (output, investment, wages, and consumption) and the extent to which this leads to the costs of the tax reduction being recovered.

Headline results

4.2 Table 4.1 below summarises the results, which are expressed as percentage increases against the baseline except for the tax recovery rate which is in terms of the percentage of the static cost that is recovered.

4.3 Following the 20 per cent real terms cut in fuel duty, which for 2016-17 has a static cost of 0.4 per cent of GDP, the CGE model suggests that GDP will be 0.4 per cent higher than the baseline after 20 years. The model also predicts that about 50 per cent of the static cost of the fuel duty reduction will be recovered in tax revenue from increased economic activity.

Table 4.1: Summary results

Steady state results (20 years)	
	CGE modelling
Difference in GDP level compared to baseline	0.4%
Difference in investment level compared to baseline	2.0%
Difference in consumption level compared to baseline	0.3%
Tax recovery rate	49%

Model description

4.4 A CGE model is a large-scale numerical model that simulates the core economic interactions of different agents in the economy. It uses data on the structure of the

economy, along with a set of equations based on economic theory, to calculate the effects that a policy change will have on the economy.

4.5 Modelling policy changes in the CGE model is a complex activity, and providing robust analysis requires an in-depth understanding of how the model works. It also requires a number of steps to be completed – checking data and model calibration, coding the logic for policy scenarios of interest, and carrying out comprehensive sensitivity analysis to check robustness of simulation results with respect to changes in model assumptions and data.

4.6 HMRC's CGE model is a single-country dynamic model. It is typically aggregated to 15 industries, 15 sectors and 15 household groups, although this can vary according to modelling requirements. The model is dynamic, so it can track the evolution of the economy over time as it reacts to policy changes, capturing the intertemporal aspect of agents' decision making. For example, if businesses are expecting a tax reduction in three years' time, this will influence their decisions about investment today. There are a number of assumptions, grounded in economic theory, about various other interactions in the economy. Information on the CGE model assumptions can be found in the HMRC CGE Model Documentation[19].

4.7 CGE models capture the inter-dependencies of the economy, meaning that a policy change or shock affecting one part of the economy will spread out through multiple transmission mechanisms simultaneously and indirectly affect the rest of the economy via feedback loops. In other words, as the name suggests, CGE models allow us to capture the effect on the whole economy from a shock or policy change impacting a sub-set of markets.

4.8 Thus, a key strength of the HMRC CGE model is the ability to model the long run dynamic macroeconomic effects and relationships across tax bases of policy changes. The main interactions and indirect effects consist of:

[19] https://www.gov.uk/government/publications/computable-general-equilibrium-cge-modelling

- inter-sectoral linkages – firms across sectors are interlinked through their use of intermediate inputs and factors of production, so a tax on one good/sector will feed through to others;
- inter-institutional linkages – links between households, firms, exporters, importers and government;
- intertemporal dynamic – the model captures the intertemporal decision making of economic agents.

4.9 Many different variables can be reported, with percentage change in GDP being the primary result. This GDP result can be disaggregated into individual components: consumption, investment, government spending and net exports, to see how these variables evolve over time.

4.10 However, the CGE model is not a short-term forecasting model. It is set up to model the transition of the economy to a new long run equilibrium following a policy change. It does not take account of exogenous short-term shocks and economic fluctuations.

Modelling the fuel duty reductions

4.11 The CGE model is used to estimate the magnitude of the economic and fiscal effects of the fuel duty rate reductions, through the different transmission mechanisms discussed in Chapter 3.

4.12 The dynamic macroeconomic effects of fuel duty reductions since the baseline year of 2011-12 are simulated, as Budget 2011 was when the first fuel duty reduction of this Parliament was announced. It is important to consider other changes since 2011 that may affect the results. Factors which affect the dynamic tax recovery rate following the fuel duty cut, such as the Corporation Tax cuts over the period, are captured fully in the baseline.

4.13 The baseline for this analysis is the fuel duty policy which was in place before Budget 2011, excluding the policy announcements made at Budget 2011. The baseline therefore assumes that fuel duty would increase by inflation (measured by RPI) plus 1 pence per litre every year from 2011-12 to 2014-15 inclusive,

reflecting announced government policy. Thereafter it is assumed to increase by inflation each year, to remain constant in real terms, as is standard for excise duties.

4.14 This analysis measures the impact on GDP of cutting fuel duty by 1 pence in April 2011 and then freezing fuel duty in nominal terms (therefore reducing it in real terms), from April 2011 to April 2015. This is done by expressing the costings (excluding behavioural response to fuel duty cuts) announced at each fiscal event as a proportion of the Budget 2011 forecast.

4.15 The reduction in fuel duty, relative to the baseline, is then used to estimate the increase in GDP that resulted from the Government's fuel duty policies since Budget 2011 inclusive. The cumulative real terms reduction in fuel duty is around 20 per cent by 2014-15. The modelling assumes households and businesses adjust their behaviour to take advantage of the cuts to fuel duty in each year, but do not anticipate future changes.

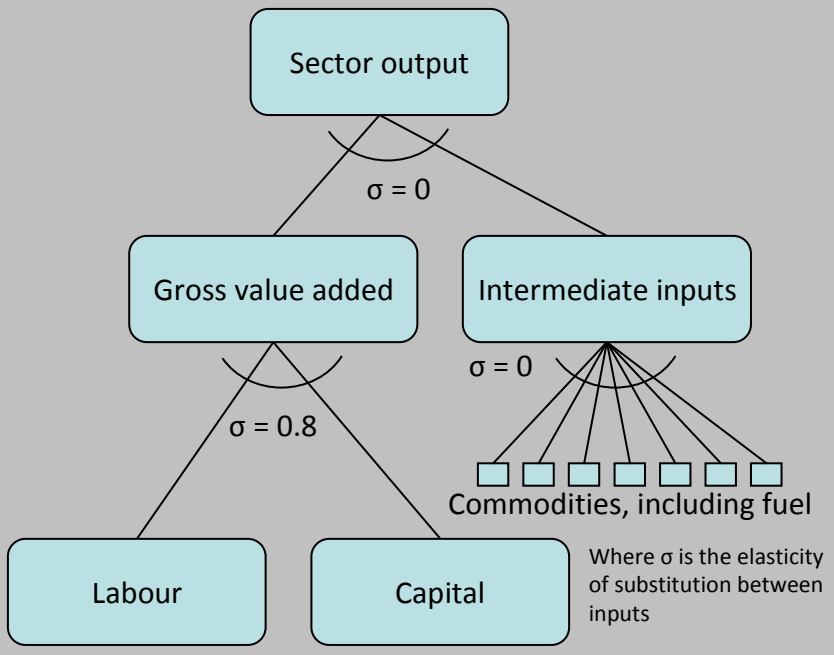
4.16 The way the government reacts to changes in its budget position (due to changes in tax revenue and spending) in each period is determined by the choice of government 'closure rules'. The closure rule used for the fuel duty simulations is the transfer closure rule, which assumes that the budget deficit resulting from a tax cut is financed through a lump sum transfer from households, after taking into account the amount of the tax recovered through the policy change. This is the same closure rule used for the CGE analysis of the Corporation Tax reductions. Using the same closure rule ensures that the results of the two papers can be properly compared.

Box 4.1: How fuel duty cuts impact on the production function of firms in the CGE model

1. Fuel enters the production function as part of firms' intermediate good use. Taken together with all other goods and services used in production, intermediate good use is then combined with value added (capital and labour) to produce output.

2. The modelling assumes that firms cannot substitute between intermediate good use and value added, and that firms cannot substitute within intermediate goods[1]. The latter assumption is relaxed for the sensitivity analysis.

3. The diagram below shows a simplified version of the nesting structure used for the modelling. Any induced technological progress due to changes in fuel duty is not captured in the modelling.



4. Following a cut in fuel duty, firms' production costs will be lower, which will be passed on to consumers as lower prices. The extent to which final prices are lower for each sector depends on the proportion of fuel used in production, and how the prices of other inputs (including capital and labour) change following the cuts. This means that different sectors will face heterogeneous cost impacts, resulting in changes to relative prices of goods and services. This will change the structure of the economy, with some sectors benefiting more than others.

[1]This is a standard CGE assumption, for example see the IFPRI model:
http://www.ifpri.org/publication/standard-computable-general-equilibrium-cge-model-gams-0

Core CGE results

4.17 Results are summarised below in Table 4.2 and Chart 4.1. When the cumulative real fuel duty rate reductions are included in the CGE simulations, GDP is estimated to be 0.4 per cent higher than the baseline position after 20 years, in response to a 20 per cent real terms cut in fuel duty.

4.18 The CGE model suggests an average fiscal multiplier[20] for fuel duty of -0.78, which means that on average for every £1 lost to the Exchequer from the fuel duty cuts, GDP would increase by 78 pence. This is broadly in-line with the empirical evidence[21] and theoretical analysis outlined in Chapter 3, that would place fuel duty at the distortive end of the tax efficiency spectrum.

4.19 The GDP effect is the result of an expansion in consumption by 0.3 per cent and investment by 2 per cent.

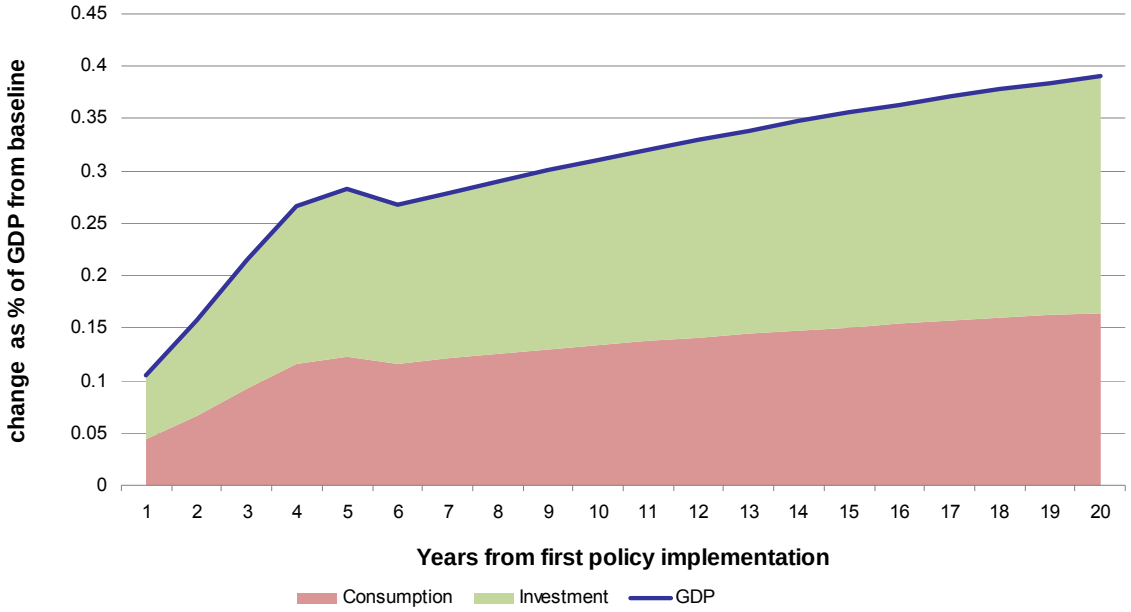
4.20 The increase in GDP leads to an expansion in most tax bases, causing 49 per cent of the static loss of fuel duty revenue to be recovered.

Table 4.2: Main CGE model results

Steady state results (20 years)	
	Main Results
Change in GDP	0.4%
Change in investment	2%
Change in consumption	0.3%
Recovery rate	49%
Fiscal multiplier	-0.78

[20] Fiscal multiplier is the ratio of a change in GDP with the change in the fiscal deficit.
[21] Parry, I. W. (2001) *"Comparing the marginal excess burden of labor, petrol, cigarette, and alcohol taxes: An application to the United Kingdom"*, Resources for the Future Inc., Discussion Paper 00-33. finds the marginal excess burden (MEB) of fuel duty in the UK to be -0.79 with a range of -0.35 to -1.8. The MEB is a comparable measure to the fiscal multiplier.

Chart 4.1: Contribution to change in GDP from consumption and investment



4.21 The expansion in GDP largely follows the fuel duty reduction schedule, low in the initial years and high after the full reduction is implemented. The decline in the growth rate of GDP in year 6 reflects the assumed uprating of fuel duty by RPI from 2016-17.

4.22 The growth in the level of GDP from the baseline is caused by higher investment and consumption. As shown in Chart 3.1, this higher consumption can be broken down to two different channels, although in practice the effects would happen simultaneously. In the first channel (shaded blue) lower fuel duty directly increases demand for fuel and road transport and leads to lower production costs, especially in fuel-intensive sectors, which through the competitive process feed through to lower final prices, stimulating consumption directly.

4.23 In the second channel (shaded orange), the increase in aggregate demand due to higher consumption means that firms need additional capital and labour to increase output. Investment expands by two per cent relative to the baseline, to meet demand for additional capital. This has the effect of increasing the return to capital as households must be induced to provide additional savings to fund higher levels of investment. The demand for labour by firms also increases which bids up wages, and the higher wages together with lower prices from the first channel lead

to higher labour supply and therefore higher overall employment across the economy.

4.24 The cut in fuel duty mainly benefits sectors for which fuel is a large proportion of their inputs. Following the cuts the transport sector expands, along with sectors that support the transport industry such as warehousing and the supply of transport infrastructure. In addition sectors that use transport as a key input into their production processes also benefit, such as the retail and manufacturing sectors, as shown in Chart 4.2. The construction sector also benefits from the cuts as manufacturing is a key input into the construction sector. Other sectors (finance, service sector and public administration) experience a minor contraction in their gross value added, as their reduction in transport and fuel costs do not fully offset the general increase in wages and capital that occurs following the cuts. The CGE model does not capture all the possible productivity effects associated with higher investment. While it captures transitory productivity effects[22], other productivity effects such as embodied innovation and technology spillovers are not captured.

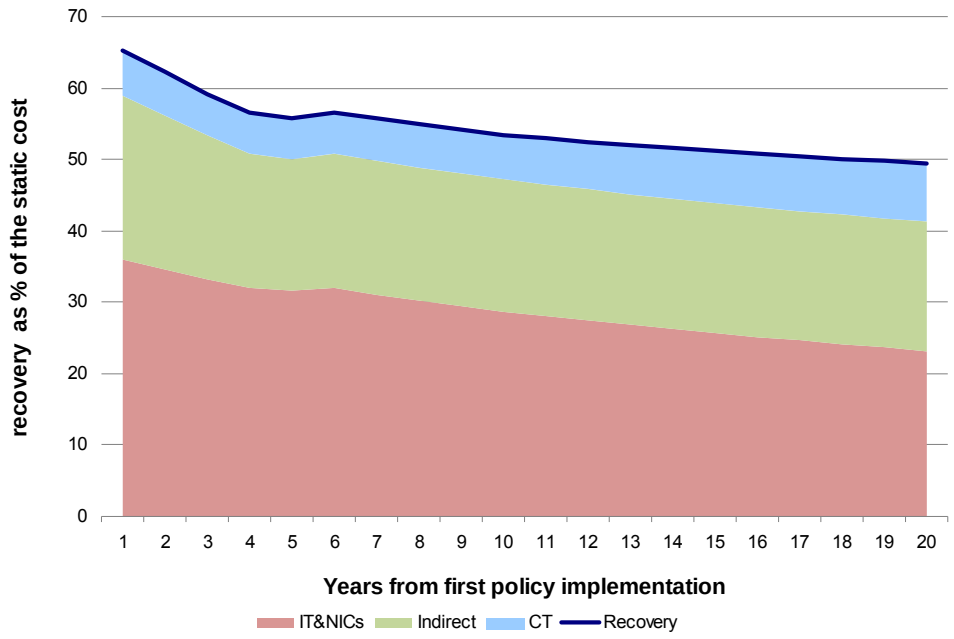
Chart 4.2: Percentage change in gross value added by sector from baseline

[22] Productivity effects arising from higher marginal productivity of labour, rebalancing capital productivity across sectors and capital stock accumulation.

CGE tax recovery effects

4.25 The increase in GDP leads to an expansion in most tax bases, causing an increase in tax revenue that makes up 49 per cent of the static loss in fuel duty revenue.

Chart 4.3: Revenue covered as a proportion of static fuel duty cut



4.26 The initial profile of the tax recovery rate follows the inverse profile of the fuel duty cuts for two reasons. Firstly, in the first year the real cut in fuel duty is relatively small (less tax to be recovered) compared to later years. Secondly reducing a tax from a high existing rate causes higher GDP than a comparable cut from a lower initial rate, because a lower tax rate is less distortive. This means that future fuel duty reductions would recover a smaller proportion of their static cost, as the initial tax rate would be lower.

4.27 The recovery rate declines to 49 per cent as real GDP increases because income tax and NICs - which accounts for most of the tax recovery (47 per cent after 20 years) - declines slightly over time. Initially receipts from income rise as the economy expands driven by an increase in employment and wages. As households get richer, and additional capital from investment becomes available, they can switch to enjoying more leisure whilst maintaining consumption levels

above the baseline. Compensation to employees still remains above the baseline, hence the positive income tax and NICs recovery even in year 20.

4.28 Corporation Tax revenues rise as the economy expands, such that additional revenues recover 8 per cent of the annual static cost by year 20. The rise in Corporation Tax revenues is caused by the expansion in the capital stock to supply the additional demand for goods and services which follows the fuel duty cuts. Corporation Tax revenue increases over the period, but it is not nearly as large a tax head as income tax, due to its lower base and lower statutory tax rate, so the recovery rate remains stable whilst real GDP increases.

4.29 Indirect tax revenues also increase, which is mainly driven by higher fuel duty revenues as demand for fuel as an input and final consumption of fuel increase following the cut. In addition, as discussed above, lower prices and higher wages and employment lead to an increase in disposable income, which in turn raises consumption levels and hence VAT and excise duty receipts. As firms expand they also demand more intermediate inputs and investment goods, some of which are indirectly taxed. The recovery attributed to indirect taxes by year 20 is 18 per cent of the static cost.

Sensitivity analysis

4.30 This section describes the results of some sensitivity analysis around the central model estimates.

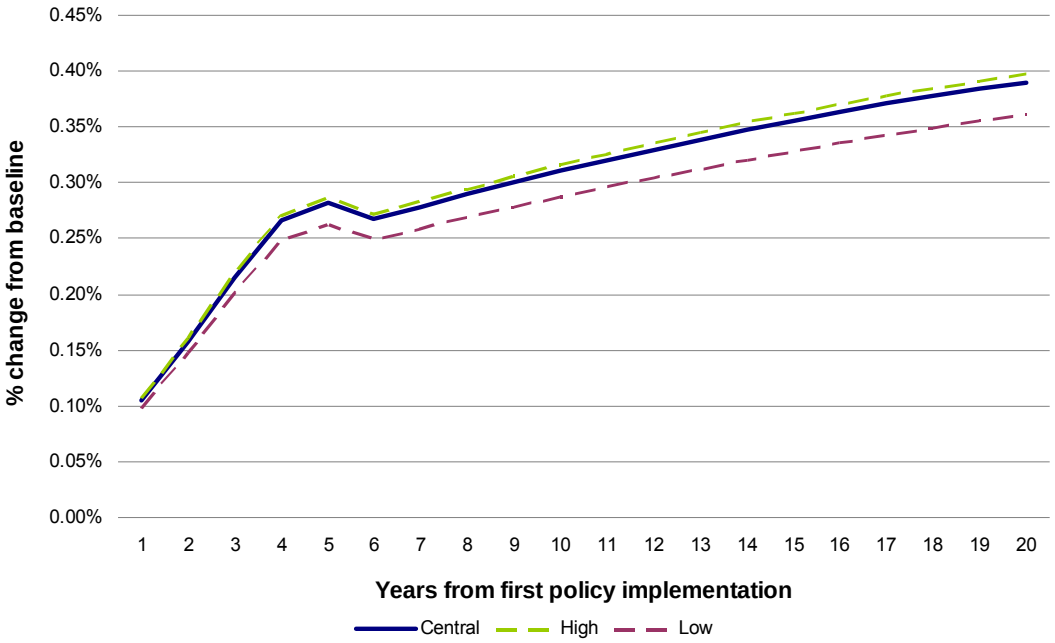
4.31 The first sensitivity relates to the intertemporal elasticity of substitution which governs how households' path of consumption over time responds to changes in current and future prices.

4.32 Chart 4.4 below shows the sensitivity of the central scenario to a high and low scenario (+/- 66 per cent of the central parameter)[23]. A higher intertemporal elasticity of substitution means households are more sensitive to price changes over time when deciding how to plan their consumption path. This means that households are more willing to save and invest (and sacrifice current consumption)

[23] The central parameter is 0.6, the high scenario is 1 and the low scenario is 0.2. For more information on the intertemporal elasticity of substitution see: Attanasio, O. P., & Wakefield, M. (2010) *"The Effects on Consumption and Saving of Taxing Asset Returns",* Dimensions of Tax Design: The Mirrlees Review.

in early years to benefit from cheaper prices in the future. This early investment leads to greater accumulation in the capital stock and therefore a higher level of GDP in the long run.

Chart 4.4: Intertemporal elasticity of substitution



4.33 A higher elasticity means that through increased investment the economy continues to grow in later periods, leading to a higher recovery rate due to higher tax receipts from each tax base. In the low scenario less tax is recovered as the effect on GDP is lower in the long run due to consumption substituting for investment in the early years.

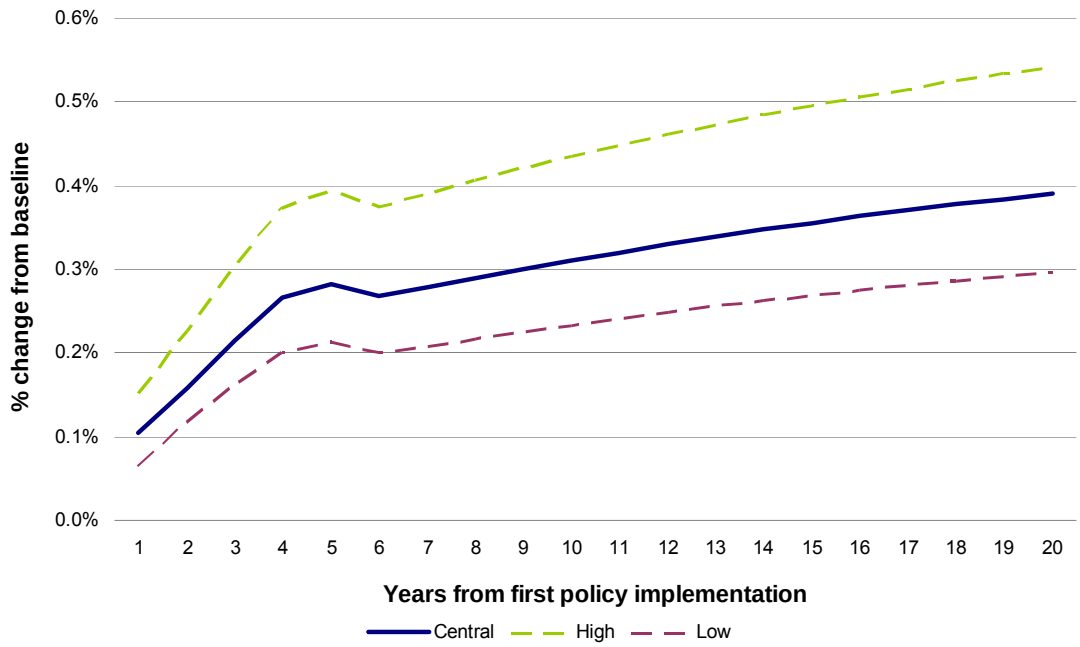
4.34 The second sensitivity modelled is the elasticity of substitution between consumption and leisure within a period. This dictates how households' consumption and leisure choices respond to changes in the price of goods, or in other words how their labour supply responds to changes in the real wage.

4.35 Chart 4.5 below shows the sensitivity of the central scenario around a high and low scenario (+/- 66 per cent of the central parameter)[24]. With a higher elasticity of

[24] The central parameter is 0.45, the high scenario is 0.75 and the low scenario is 0.15. For more information on the elasticity of substitution between consumption and leisure see: Gunning, T. S., Diamond, J. W., & Zodrow, G. W. (2008) *"Selecting Parameter Values for General Equilibrium Model Simulations."* The James A. Baker III Institute for Public Policy, Rice University, mimeograph.

substitution between consumption and leisure households are willing to work more in order to spend money on goods and services, which have become relatively cheaper after the fuel duty cuts. This increase in consumption results in a higher GDP compared to the central scenario. In the low elasticity scenario households are less willing to trade-off consumption for leisure and so the effect on GDP is lower.

Chart 4.5: Elasticity of substitution between consumption and leisure

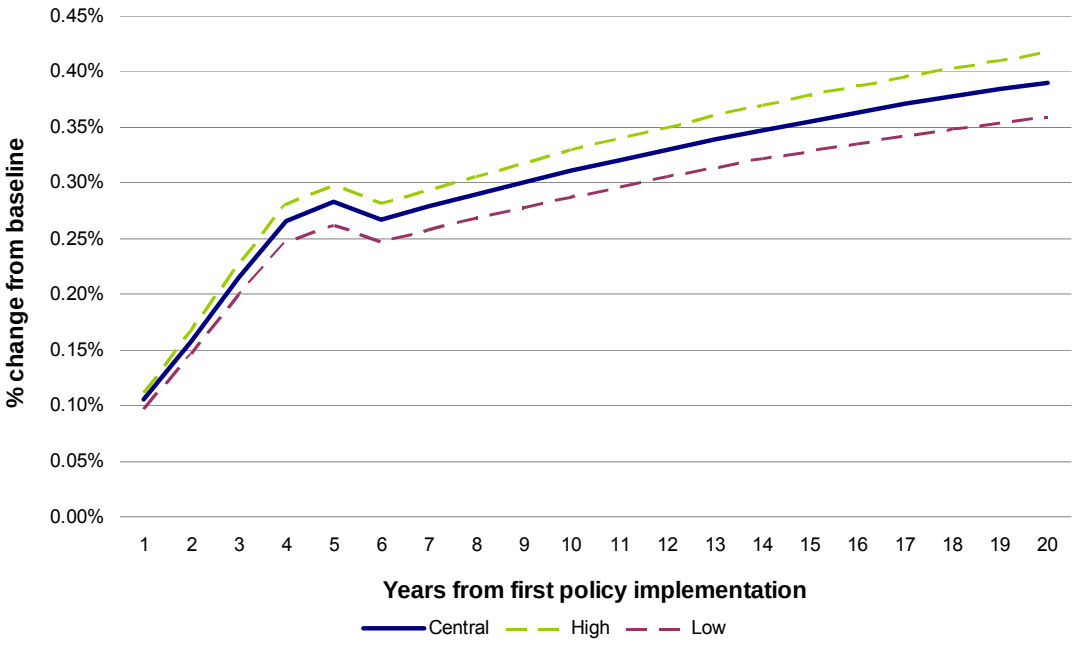


4.36 Changing this elasticity of substitution has a similar effect on the recovery rate, with the low scenario providing less tax recovery, due to a smaller effect on GDP, whereas the high scenario provides a higher tax recovery as the economy is larger compared to the low scenario.

4.37 The third sensitivity modelled is elasticity of substitution between capital and labour. Firms produce goods and services using inputs of labour, capital and intermediate goods. Firms may decide to employ capital and labour in different proportions. How these proportions change in response to changing factor prices is governed by the elasticity of substitution between capital and labour. Chart 4.6 below shows the sensitivity of the central scenario around a high and low scenario

(+/- 50 per cent of the central parameter)[25]. A higher elasticity makes it easier for firms to substitute capital for labour. This results in a greater increase in GDP following the fuel duty cuts.

Chart 4.6: Elasticity of substitution between labour and capital

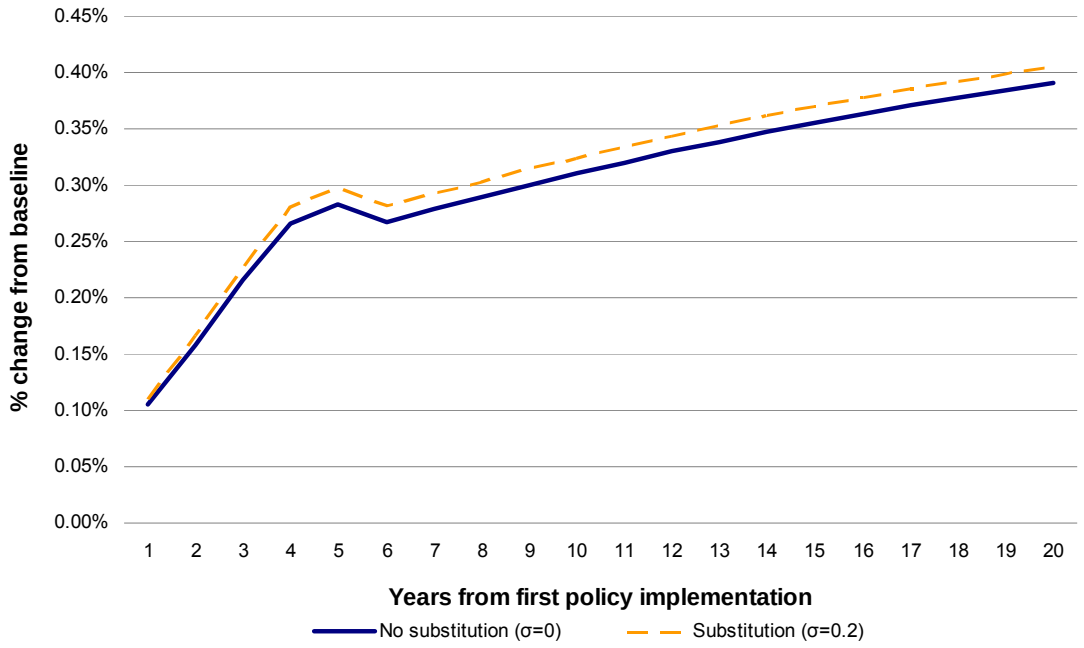


4.38 Changing this elasticity of substitution has a similar effect on the recovery rate. In the low scenario there is less tax recovery, due to a smaller effect on GDP, whereas in the high scenario there is a higher tax recovery as there is more economic output compared to the central scenario.

4.39 As shown in Box 4.1 the model does not allow businesses to substitute between different intermediate goods. This is a reasonable assumption because the CGE model uses an aggregation of 15 sectors. Therefore, whilst businesses are likely to substitute within one sector when the prices change, for instance, substituting one type of computer for another when the relative prices change, they are unlikely to substitute across sectors, for instance, from a computer to raw materials like steel.

[25] The central parameter is 0.8, the high scenario is 1.2 and the low scenario is 0.4. For more information on the elasticity of substitution between consumption and leisure see: Gunning, T. S., Diamond, J. W., & Zodrow, G. W. (2008) *"Selecting Parameter Values for General Equilibrium Model Simulations."* The James A. Baker III Institute for Public Policy, Rice University, mimeograph.

Chart 4.7: Elasticity of substitution between intermediate goods



4.40 Chart 4.7 shows that allowing businesses to substitute between intermediate goods increases the impact on GDP. This is because businesses are able to switch some of their current intermediate goods for fuel to take advantage of the lower prices. This allows them to change their mix of intermediate goods to a more efficient allocation, leading to increased output.

4.41 Whilst the effect on GDP is not substantial, the effect on the recovery rate is more significant with a long-run recovery rate of 56 per cent. This is caused by the increased use of fuel by businesses, relative to other inputs, as a result of the tax cuts.

4.42 Table 4.3 summarises the GDP and tax recovery rates from the above sensitivity analysis.

Table 4.3: Summary of the sensitivity analysis

Steady state results (20 years)			
Sensitivity	**Scenario**	**GDP**	**Recovery rate**
Elasticity of intertemporal substitution	High	0.40%	53%
	Central	0.39%	49%
	Low	0.36%	37%
Elasticity of substitution between consumption and leisure	High	0.54%	52%
	Central	0.39%	49%
	Low	0.30%	45%
Elasticity of substitution between Labour and Capital	High	0.42%	56%
	Central	0.39%	49%
	Low	0.36%	41%
Elasticity of substitution between intermediate inputs	High	0.40%	56%
	Central	0.39%	49%
Range of results	Low to High	0.30% to 0.54%	37% to 56%

Chapter 5 – Conclusions

5.1 This report shows the results of applying the CGE model to the fuel duty reductions announced since 2010. The Government will have eased the burden on motorists by £22.5 billion over this Parliament to 2015-16. Fuel duty in real terms is forecast to fall over this Parliament by 13 per cent. Had the Government implemented the fuel duty escalator, rates would have increased by 7 per cent. As a result, from 1st April 2014, pump prices will be 16 pence per litre lower than if the Government had implemented the fuel duty escalator, and will be nearly 20 pence per litre lower by the end of the Parliament.

5.2 HMRC's CGE model can be used to model the dynamic macroeconomic effects of a cut in fuel duty, as well as the resulting effect on tax receipts.

5.3 As a tax which falls on businesses, as well as households, and was set at a high rate in 2010, the model shows fuel duty to be one of the most distortive taxes, with a reduction in rates generating significant dynamic effects. Important factors in determining the size of the GDP effect include the proportion of tax falling on business inputs and the initial tax rate, which in 2010 was particularly high. Because of this the first fuel duty reduction has the largest effect, with a diminishing GDP impact as the tax rate falls further for subsequent cuts. The CGE model captures the main channels through which a reduction in fuel duty affects GDP – these are consumption, investment and prices.

5.4 Modelling work suggests in the long-term reductions in fuel duty will result in an increase in GDP against the baseline of between 0.3 and 0.5 per cent. This leads to between 37 and 56 per cent of the static cost of the reductions being recovered.

5.5 This is the second publication of dynamic analysis using the CGE model. Previous analysis found an increase to GDP of 0.6 to 0.8 per cent for the reduction of Corporation Tax from 28 per cent to 20 per cent (a slightly larger static cost than the fuel duty reductions), with 45 to 60 per of the static cost being recovered.