Tradable Carbon Permits: their potential to reduce CO_2 emissions from the transport sector

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Submitted in accordance with the requirements for the degree of PhD

The University of Leeds

Institute for Transport Studies

November 2007

The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

Acknowledgements

Firstly I would like to thank my supervisors, Dr Miles Tight, Professor Abigail Bristow and Dr Astrid Guehnemann for all of their much appreciated advice and encouragement throughout. I would also like to thank my husband who has given me unlimited amounts of support, encouragement and enthusiasm. I would like to show my appreciation to a number of people who have helped along the way: Peter Balmforth for his help with the software, Richard Starkey for his support and useful discussions particularly during the first part of the research, and all of the people who took part in the surveys.

I would also like to thank the Engineering and Physical Sciences Research Council for funding this research and also the Institute for Transport Studies for their allocation of strategic funds in the later stages.

Abstract

Given the severity of the impacts arising from climate change and the short timeframe available regarding mitigation, it is imperative to reduce emissions of greenhouse gases. Road transport is a significant contributor to UK CO_2 emissions, with the majority arising from personal road transport. A working model of a Tradable Carbon Permit (TCP) scheme was therefore designed to achieve a 60% reduction of CO_2 emissions from personal road transport by 2050. A proportion of the annual carbon budget would be given to individuals as a free carbon permit allocation. Following the consumption of the free carbon permits, an individual must then purchase any permits required in the future from a centralised market. Alternatively, there is an opportunity to sell unused permits.

Fuel price increases were recognised as having the potential to achieve an identical emissions target at a much lower cost. Hence, conventional elasticities were used to derive a comparative measure to the TCP scheme. A range of practical considerations regarding both policies were discussed, including approximate costings, social impacts and implementation.

An innovative survey design was developed to explore the feasibility of applying a TCP scheme and a system of fuel price increases (FPI) to the personal road transport sector. A series of individual interviews were conducted to gather opinions related to the impacts (including costs and benefits), effectiveness (ability to meet the emissions target), fairness and acceptability of both measures. Bespoke software was used to record behavioural response and display respondents' travel data alongside their free permit allocation and estimated spending at three points in time. A range of qualitative and quantitative results are reported. The findings revealed a stark contrast in opinions and attitudes towards the TCP scheme and FPI, with the TCP scheme being more favourable in every aspect in addition to achieving a much greater level of behavioural response and hence carbon reductions.

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Chapter 1

Introduction

Transportation is an intrinsic part of society and current lifestyles (Lyons *et al.*, 2002; Anable, 2005). However, there are major detrimental impacts of fossil fuelled transport in terms of resource depletion and environmental degradation. Given the widely acknowledged importance of limiting the impacts of climate change and the significant contribution to carbon emissions from transport, this research seeks to both identify a method for achieving crucial reductions of carbon emissions and to explore public response.

1.1 Environmental impacts: local and global

Emissions from transport contribute significantly to levels of local air pollution in the UK, accounting for the majority of Nitrogen Oxides (NO_x), particulate matter (PM_{10}), Carbon Monoxide (CO), Benzene and 1,3 butadiene. Whilst there are detrimental impacts on the environment, such as acid rain production resulting from NO_x, the impacts of local air pollutants on human health are also highly undesirable with an estimated 24,000 premature deaths each year as a result of exposure (DoH, 1998; COMEAP, 1998).

Emissions from transport also contribute greatly to greenhouse gas (GHG) production. GHG's are an essential component of the atmosphere as without them the earth would be uninhabitable. However, anthropogenic (human produced) GHG emissions are contributing to warming of the climate beyond what would be naturally expected. Carbon Dioxide (CO_2) is classified as the most significant GHG due to the quantity of release and quantity present in the atmosphere (IPCC, 2007). The UK contributes 2% to global GHG emissions, of which the transport sector is responsible for 28% of CO_2 emissions and is forecast to increase in comparison to declines in other sectors (DEFRA, 2006a). The predicted impacts of climate change are farther reaching and on a much larger scale than those related to local air pollution.

Evidence of climate change is already apparent. A recent report by the Intergovernmental Panel for Climate Change (IPCC) (IPCC, 2007) states that there is high confidence that recent changes in temperature have had discernible impacts on many physical and biological systems. Observational evidence from continents and oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases. The observations include an enlargement and increased number of glacial lakes and increasing ground instability in permafrost regions. Based on the evidence available, the IPCC (2007) conclude with high confidence that anthropogenic warming over the last three decades has had a significant influence on many physical and biological systems. Additional evidence is emerging regarding the impacts of warming on human systems including effects on agricultural and forestry management in the higher northern hemisphere latitudes; an increase in heat related mortality in Europe and infectious disease vectors in some areas. For example, the heat wave during 2003 caused the premature death of 14,000 people in France (DoH/HPA, 2007). Due to limitations in evidence available the IPCC (2007) have medium confidence regarding the anthropogenic influence on human systems.

Future warming is predicted to have numerous impacts. For example, by mid-century annual water availability is projected to increase by 10-40% in high latitude areas and decrease by 10-30% over some dry regions at mid-latitudes. There is likely to be an increase in the extent of drought-affected areas whilst heavy precipitation events are likely to increase in frequency thus increasing flood risk. Up to 30% of species will be at increasing risk of extinction and around 30% of global coastal wetlands will be lost with millions more people experiencing coastal flooding each year. Predicted human health impacts include malnutrition, cardio-respiratory and infectious diseases and an increase in morbidity and mortality from heat waves, floods and droughts thus resulting in a substantial burden on health services. In the longer term, there is medium confidence that the partial melting of the Greenland and West Antarctic ice sheet as a result of 1°C - 4°C global average temperature increase would cause a sea level rise of 4-6 metres or more. Complete melting of the Greenland and West Antarctic ice sheet would result in a sea level rise of up to 7 metres (IPCC, 2007b). As a result of such impacts, there is expected to be a mass migration of populations to less affected areas, hence a huge pressure on resources world wide.

1.2 Political action

In light of such evidence, the G8 reached an agreement in 2005 regarding the role of human activity in climate change and the need for urgent action. It was agreed that GHG emissions need to slow, peak and reverse and that G8 countries need to make substantial cuts. Furthermore, at its 33rd G8 summit in June 2007, the G8 agreed to aim to at least halve global CO_2 emissions by 2050 from current levels. However, binding figures were not set as the president of the USA would only agree to such reductions if China and India were also included in the commitment (Elliot and Wintour, 2007). Whilst the G8 agreement is a major step forward in terms of climate change policy, recent scientific evidence suggests that in order to avoid going beyond a 2 °C increase in global temperature and thus avoid the most severe and irreversible climatic change, it would be necessary to reduce CO_2 emissions by 70% - 90% by 2050 (Bows *et al.,* 2006; Stern, 2006).

The UK government set out aims in the Energy White Paper (DTI, 2003) to achieve a 60% reduction of UK CO_2 emissions by 2050. This target is proposed to become legally binding, with a draft climate change bill outlining the necessary legislation (DEFRA, 2007). The majority of CO_2 emissions resulting from transport in the UK are a result of road transport, of which the majority is for personal uses (DEFRA, 2006a). Whilst air transport is the fastest growing source of CO_2 emissions, at a national level personal road transport currently accounts for a much larger amount (26% compared to 1%) (DfT, 2006a). The UK government currently have a range of transport policies set out in the

Climate Change Programme that are expected to deliver a reduction of CO_2 emissions from transport by 13% by 2010 from growth trends (in comparison to taking no action) (DEFRA, 2006b). The main policies are outlined in the following sections.

1.2.1 Pricing

In the 2006 Budget, Vehicle Excise Duty (VED) was altered in order to encourage the use of the lowest CO_2 emitting vehicles by making vehicles in the lowest CO_2 emitting band exempt from VED. Furthermore, in the 2007 Budget the price of VED for the 2nd lowest CO_2 emitting band was reduced whilst the price for vehicles in the highest CO_2 band was increased with plans to further increase this in 2008 (DTI, 2007). In addition, fuel duty was increased by 2 pence per litre in October 2007 with similar increases planned in 2008 and 2009.

1.2.2 Regulation

In November 2005 the Renewable Transport Fuel Obligation (RTFO) was introduced requiring by 2010 that 5% of all fuel sold on UK forecourts originates from a renewable source. The alternative Fuels Framework aims to promote the development of sustainable alternatives to fossil fuel. The government is committed to a 3 year rolling guarantee for biofuels and road fuel duty rates, with a 20 pence per litre price incentive for bioethanol and biodiesel until 2008-09 (DEFRA, 2006b). The 2007 Budget extended the 20 pence price differential for biofuels to 2009 -10. Together with the RTFO, this results in a 35 pence per litre price incentive.

1.2.3 Voluntary agreement

If successful, the UK could also benefit from the voluntary agreement that currently exits between the European Commission and European and Asian car manufacturers (ACEA/EC, 1998). The aim is to achieve a European average of 140 grams of CO_2 per kilometre for all new cars by 2008 with ambitions to achieve an average of 120 grams of CO_2 per kilometre for all new cars by 2010. The UK government are hoping to achieve further efficiency gains beyond 120 grams of CO_2 per kilometre by supporting the expansion of the agreement beyond 2010 (DEFRA, 2006b).

1.2.4 Future policy direction

The measures outlined in sections 1.2.1 to 1.2.3 are expected to reduce CO_2 emissions from transport by 13% by 2010 (in comparison to taking no action) (DEFRA, 2006b). However, this reduction can not be guaranteed due to the reliance on market response in terms of willingness to pay and the uncertainty regarding the fulfilment of the voluntary agreement. The measures are likely to have an impact on CO_2 emissions but will not deliver the significant reduction necessary in order for the UK to achieve a legally binding 60% reduction by 2050. Whilst it is possible that it may be more cost effective to reduce CO_2 emissions in other sectors, in consideration of the possible need to achieve a 90% reduction of UK carbon emissions (Bows *et al.,* 2006), significant reductions from the transport sector are unavoidable. Thus, a new policy direction is essential. In recognition of the potential to deliver substantial carbon reductions (DEFRA, 2006b; Roberts and Thumin, 2006), the government have begun to explore the concept of personal carbon trading as a key climate change policy tool.

1.3 Research aims and objectives

A personal carbon trading scheme could potentially achieve significant reductions with high confidence and hence could be a key contributor in terms of attaining legally binding CO_2 reduction targets (Starkey and Anderson, 2005; DEFRA, 2007, Roberts and Thumin, 2006; Fleming, 2007). However, there are currently no detailed designs setting out how such a scheme would work in practice including estimated financial costs. In addition, there is no empirical evidence available regarding public response and implied policy effectiveness. Hence there is clearly a knowledge gap which requires significant input in order to determine whether a personal carbon trading scheme should progress beyond the concept stage to become a key climate change policy tool. This research therefore aims to undertake the first major investigation into the feasibility of personal carbon trading. More specifically, the research aims to:

1. Explore the feasibility of a personal carbon trading scheme used to achieve a significant reduction of UK CO_2 emissions from personal land based transport.

In particular, the policy design, ability to achieve emissions targets and public response are identified as key research areas. Hence, the research aim will be achieved through the following objectives:

1. Fully design a working personal carbon trading scheme for land based transport including estimated financial costs.
2. Explore behavioural response to a personal carbon trading scheme.
3. Explore public attitudes to a personal carbon trading scheme.

This research therefore aims to implement an innovative and interactive survey design in order to provide a first set of empirical data regarding the feasibility of a personal carbon trading scheme in terms of policy design, public attitudes and behavioural response.

The following chapter serves to explore the scope for personal carbon trading in the transport sector. Chapter 3 details the design of the personal carbon trading scheme, followed by the survey design and implementation. Chapter 4 provides survey results on environmental attitudes, with the behavioural response presented in chapter 5. Chapters 6 and 7 contain further survey results regarding attitudes including perceived effectiveness and acceptability ratings. Finally, chapter 8 provides the research conclusions, key findings, policy implications and recommendations for future research.

Chapter 2

A review of Tradable Permit schemes and their potential to reduce carbon emissions from personal transport

This chapter aims to explore in detail the scope for using a personal carbon trading scheme to achieve a significant reduction of carbon emissions from personal transport. Section 2.1 provides an overview of Tradable Permit (TP) schemes, with a more detailed look at the typical components of such a scheme in section 2.2, followed in section 2.3 by possible scheme designs. Section 2.4 reviews several examples of current and past working TP schemes, highlighting the points of success and failure. Section 2.5 explores recent developments in emissions trading and outlines the political interest in the UK. Possible approaches to personal trading for all personal energy use in the UK are described in section 2.6, whereas section 2.7 details the possible approaches to emissions trading in the transport sector including perceived strengths and weaknesses in section 2.8. Section 2.9 evaluates the benefits and beneficiaries of a personal carbon trading scheme applied in the transport sector. The public support for a personal carbon trading scheme is explored in section 2.10. Following this, section 2.11 outlines a carbon tax on fuel as a possible alternative measure to a personal trading scheme. The final section provides conclusions from the chapter.

2.1 Introduction to Tradable Permit schemes

TP schemes are economic measures designed to achieve environmental targets at the lowest possible social costs. They have the potential to achieve targets set under traditional 'command and control' measures but at much lower economic costs (Verhoef *et al.*, 1997) as pollution credits can be transferred amongst those who are better equipped to make the desired changes (e.g., a reduction in emissions produced) and those for whom the market prices are more economically feasible than abatement technology at that time. TP schemes therefore provide flexibility and enable new requirements to be achieved in a more cost effective manner.

The use of TP schemes as a means of environmental regulation was proposed by an economist in 1968 (Dales, 1968). Following this work, the cost-effectiveness of TPs as a regulatory measure was proven in a theoretical setting (Verhoef *et al.*, 1997). Tradable permit systems have since been applied to point source emissions which are, under normal circumstances, regulated by command and control measures. Examples include atmospheric pollution (Emissions Trading Programme; Ozone Depleting Chemical programme; SO_2 allowance trading programme; Regional Clean Air Incentives Market (RECLAIM)); the transport sector (between oil refiners (lead in gasoline programme); between vehicle manufacturers (Zero Emissions Vehicle programme)); the fisheries industry (Individual Transferable Quota); water resource management and pollution control; and land-use management (Development rights programmes) (OECD, 1999). Whilst this chapter will focus upon the application of TPs in the transport sector, examples from other sectors will be used where appropriate.

2.2 Components and workings of a Tradable Permit scheme

There are several key components that make up a TP scheme. These include the aim of the scheme and hence the emissions reduction targets, the basis for permit allocation, the distribution of the permits and the scope (for example the geographical area to be covered and the types of emissions sources considered). The following sections describe the key components of a working TP scheme.

2.2.1 Targets

TP schemes are typically designed to achieve an emissions reduction target. To date they have usually regulated stationary sources of pollution, however TPs could also be used to regulate emissions of gas or liquid from stationary or mobile sources. Achieving the overall reduction target can be set out in stages, for example with rolling annual sub-targets, or by setting a decadal target in a long term scheme. The targets can sometimes vary over the lifetime of the scheme, for example if annual sub targets were applied, these could be low in the first five years and increased over time as more opportunities for emissions reductions became available. Alternatively, a linear reduction could be applied, having the advantage of a set reduction each year which is understood and known to the trading entities.

2.2.2 Permit allocation

The aim of the TP scheme informs the commodity to be traded. For example, if the aim was to reduce sulphur dioxide, the commodity to be traded would be permits each equating to a set amount of sulphur dioxide. Due to the equity impacts, the initial distribution of permits is extremely important (Verhoef *et al.*, 1997). There are four main ways of allocating permits as described in the following sections.

2.2.3 Grandfathering

The 'grandfathering' principle is commonly used in tradable permit schemes where allocations are based upon historic emissions patterns and appears to have a high degree of acceptability amongst participants as it causes little disruption to existing patterns and minimises the financial burden placed upon users. For example, a company currently emitting the equivalent of 100 permits would be given 100 permits free of charge as an initial allowance, which would be reduced over time in line with the emissions target (Cramton and Kerr, 2002). If the company did not reduce their consumption in line with their permit allocation, they would have to buy more permits, thus providing an incentive to consume within the allocation. Research conducted in the US by Svendsen (1999) revealed a preference amongst the private business market for a TP scheme using a grandfathered permit distribution. The preference was a result of the recognised benefits in terms of favouring existing sources financially and, moreover, creating a barrier to new market entrants.

The grandfathering approach is used to allocate permits in the European Emissions Trading Scheme (EU ETS) (see section 2.4). As the permits are normally distributed free of charge, the grandfathering approach does not provide any revenue for the government, thus requiring the scheme to be funded from external revenue. Grandfathering does not consider new market entrants who would be disadvantaged by having to purchase permits rather than receiving them free of charge, which is a major drawback of this approach (Tietenberg, 2000). Moreover, the inclusion of new entrants could increase emissions, thus making this allocation method ineffective in terms of attaining the emissions target. Grandfathering would be unsuitable for a trading scheme where individuals were the trading entity due to the problematic process involved in establishing historic emissions levels. In addition, there would be significant equity concerns regarding the inclusion of new entrants.

2.2.4 Auctioning

Auctioning involves trading entities buying all of their permits from the government. This has the advantage of creating funds that could be invested into the further development of the trading scheme or other supporting measures and reducing the financial burden. However, this method is much less popular than the grandfathered approach as users must buy all permits rather than be allocated a proportion free of charge. There are also equity issues in this approach as those with greater financial power are able to buy as many permits as they require, rather than each user receiving an equal amount free of charge. However, this could be partly resolved by placing a limit on the amount of permits an account could hold and the amount of permits that could be purchased at any one time. Auctioning can be used where either individuals or businesses are the trading entities.

2.2.5 Updating

Updating involves an allocation based upon information on use which is updated over time. This method is popular with users but has disadvantages; in particular users are able to increase their allocation by using more permits each year, thus increasing their allowance for the following period (Crals *et al.*, 2003). This system is therefore ineffective as it may encourage greater use of the commodity rather than a reduction.

2.2.6 Free distribution

Permits could be distributed equally amongst participants free of charge, the main advantage being the high degree of social and political acceptance (Keppens and Vereeck, 2003). A disadvantage would be that no additional funds are created for the government or the operator of the scheme. However, this could be resolved by using a combination of methods, such as distributing a proportion of permits free of charge and auctioning the remainder. Permits could be allocated on an equal per capita basis, which is regarded as the most equitable method, or by taking into account, for example where individuals are the trading entity, socio economic data relating to personal characteristics which influence transport activity, such as age, family size or job type. For businesses, permits could be allocated based on the size of the business or, for example, on the efficiency of current practices.

In practice many schemes are likely to use a combination of the allocation methods described above.

2.2.7 Tradability

Permits can be tradable or non-tradable. Tradable permits can be passed between trading entities until they are finally consumed whereas non-tradable permits can only be used by the entity they were allocated to i.e. unused permits could not be sold. Most permit schemes use tradable permits as this achieves greater efficiency within the system as unused permits can be sold rather than 'wasted', hence reductions are made at the lowest cost. Those who are able to reduce their emissions easily can do so and sell their excess permits to those who cannot reduce their emissions as easily or as cost effectively. Tradable permits therefore provide an incentive to reduce below the allocation in order to benefit from selling excess permits on the open market.

2.2.8 Geographical area

Another important aspect of an emissions trading scheme is the geographical area to be covered within its remit. This could be on a regional, national or international level. Typically, previous schemes have been implemented at a national level, with the exception of the EU ETS which includes all power stations and energy intensive industries across the EU (see section 2.4). However, one of the emissions reduction measures outlined in the Kyoto Protocol is an international emissions trading programme, to become operational in 2008 (UNFCCC, 1992). It is also possible to apply an emissions trading scheme to a particular industry, sector or mode by clearly defining the target and eligibility criteria.

2.2.9 Temporal flexibility

Within an emissions trading scheme, there can be an element of flexibility either in terms of meeting emissions targets or distributing permits. Annual targets could be set, which could be waived if banking of emissions credits is included in the policy design, as this could possibly result in the over achievement of the target during a year where permits were in high supply and banked for later use, leading to underachievement in subsequent years when permit availability is reduced in line with the overall emissions target. Flexible release of permits is a strategic option that could minimise the risk of permit shortages where annual targets are employed, for example permits could be released gradually during the year rather than all at the beginning of the year. Placing a limit on the amount of permits a permit account could hold at anytime and the flexible release of permits could also reduce the scope for profiteering. However, there are potential impacts resulting from the various methods of temporal flexibility which should be considered prior to implementation. For example, in some circumstances it may be necessary to have a high level of permits in an account, hence, any limitations could be considered unfair.

2.3 Scheme design

There are various ways to design and implement a TP scheme. This section describes the main approaches.

2.3.1 Baseline and credit

In a baseline and credit scheme, permits must be earned before trading can begin (UNEP, 2003). A baseline consumption of the resource is established for each user. A period of time is then allowed where users can reduce their consumption, known as the compliance period. After the set compliance period, consumption is recalculated and where actual emissions are lower than the baseline, users are given credits equal to the difference. For example, if a company had a baseline consumption of 10 units prior to the compliance period and 8 units following the compliance period, they would be credited with 2 units which they could either use or trade. If actual emissions are higher than the baseline, the user must purchase credits equal to that amount in order to achieve compliance (UNEP, 2003). Examples of baseline and credit schemes include the leaded gasoline program and the heavy duty engine emissions standards program (UNEP, 2003).

A major disadvantage of this method is the establishment of an emissions limit for each user, rather than the whole market. This could lead to an increase in emissions if new users enter the market (Tietenberg, 2000). A baseline and credit scheme is more suitable where companies are the trading entity, due to the difficulty involved in establishing baselines for individuals.

2.3.2 Cap and trade

The cap and trade approach involves the establishment of an overall emissions reduction target or a 'cap' on emissions. Emissions allowances, rather than credits, are then provided to each end user (Tietenberg, 2000). Unlike the baseline and credit approach, the trading entities do not have to provide a baseline consumption, nor are they given a compliance period in which to reduce their baseline. Instead, permits are allocated and users then surrender the amount of permits equivalent to their consumption back to the regulating body. If more permits are required, users can buy from those who have excess permits to sell. The allocation of allowances can vary between schemes, depending on the method adopted (see section 2.2.2 for methods of permit allocation). The major advantage of this method is the high potential to achieve a set emissions target at a national or international level. An example of a cap and trade scheme is the American ozone depleting substances program (UNEP, 2003). As a baseline consumption is not required, such a method would also be suitable to apply amongst individuals.

2.3.3 Open and closed systems

An open scheme allows smaller emitters to opt in on a voluntary basis. Participants would have the same compliance regulations as the non-voluntary emitters and would only opt in if they expected to be able to reduce emissions in a less costly way and have surplus permits to sell.

Closed emissions trading schemes often only include a small fraction of the total number of emissions sources, due to the administrative burden and financial costs involved, rather than covering all sources of the regulated emissions. For example, inclusion of small mobile emitters and large emitters could result in the costs of the scheme outweighing the benefits received. Examples of closed schemes include the EU ETS, which includes only stationary sources of CO_2 from power stations and energy intensive industries, such as steel and cement, within the European Union (see section 2.4).

2.3.4 Voluntary versus mandatory schemes

A trading scheme can be enforced, where all trading entities would have to comply, or it can be introduced on a voluntary basis where entities can opt into the scheme if they recognise the benefits of doing so. The latter option is likely to incur greater levels of political support, however, it could be more problematic to achieve a set emissions target. A voluntary scheme would be most effective where there is a choice between, for example, paying a tax on the commodity for all purchases or opting into a trading scheme where a free allocation of permits would be provided, thus enabling a certain amount of the commodity to be purchased at no additional cost.

A mandatory scheme is likely to be more effective at achieving an emissions reduction target and provides greater certainty of attainment within a set period of time, whereas the voluntary approach could take much longer to achieve the same level of emissions reduction. A scheme would be enforced, rather than voluntary, where political acceptability is perhaps not such a fragile issue, and where it is imperative to achieve a set emissions target within a certain timeframe.

2.4 Applications of Tradable Permits in environmental regulation: successes and failures.

A worthwhile procedure for any policy maker is to determine the factors within previous policies that contributed to their success or failure, in order to avoid or implement such factors into future schemes. This section of the review is therefore designed to summate, rather than detail, the key points from a selection of previous applications of TP schemes which contributed to the success or failure.

The first TP scheme was implemented in the USA during the mid 1970's. The Emissions Trading Programme (ETP) was designed to add flexibility to stationary sources in meeting the air quality standards required by the Clean Air Act 1975 (Tietenberg, 1985). The system has been successful in achieving emission reductions at significantly lower costs than those incurred without the system (Hahn, 1989). However, the ETP has been described as "falling far short of its cost-reducing potential" (Harrison, 1999, p.27). The main reason for the shortfall was the many procedural requirements and restrictions placed upon allowable trades (each trade had to be rigorously evaluated and certified by the Environmental Protection Agency), which together increased the cost of trading and caused uncertainty and delay. As a result, many companies did not trade, with the majority of trading carried out internally rather than between plants or companies.

Conversely, the Lead-in-gasoline programme, established in 1982 with a purpose of reducing Lead in gasoline from 1.1 to 0.1 grams per gallon over a five year period, has been rated a success. There are several reasons for the success of the scheme, although it was mainly attributable to the transparency of the scheme - the commodity to be traded (grams of lead) and the trading mechanisms were well established with all participants which removed any uncertainty. In addition, trading was unrestricted, therefore allowing traders to trade without the need for permission or certification from the authorities.

Other factors contributing to the success of the scheme were the decline in consumption of leaded gasoline and the availability of affordable technological solutions for replacing lead in gasoline (Raux, 2002). One criticism of the system was that permits were not individually identifiable; therefore bogus permits were very difficult to trace. Regulators in the Los Angeles air basin took this negative aspect of the Lead in gasoline system into account when designing the Regional Clean Air Incentives Market (RECLAIM) programme, which was designed to reclaim good air quality and a stable economy. Beginning in 1994, the programme features an Allowance Tracking System in order to control unorthodox permit transfers and use (Harrison, 1999).

A vital ingredient for a successful TP system is a strong political will (OECD, 1999). Without this a system is unlikely to survive, or targets may be reduced, as a result of protest and objections. For example, the Zero Emissions Vehicle programme, designed to reduce emissions from gasoline-powered vehicles in California, was reformed in 1996 when targets to be met in 1998 (seven of the most important American and Japanese automakers were required to ensure that at least 2% of the vehicles delivered for sale in California were ZEVs[1]) were extended to 2003 and voluntary agreements were made with vehicle manufacturers rather than enforcing the initial mandatory plans. These actions were viewed as victories for the vehicle manufacturers (Raux, 2002).

Some TP schemes have not progressed beyond the design stage. For example, plans to implement a SO_2 trading programme in the UK were hindered mainly by coinciding regulatory measures imposed upon the European Union (the Large Combustion Plant Directive; UNECE Second Sulphur Protocol; the Air framework Directive; BATNEEC[2]; and the Integrated Pollution Prevention and Control Directive) that rendered the system ineffective. Other factors reduced

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[1] Genuine Zero Emission Vehicles must have no tailpipe or evaporate emissions, or any emissions from fuel production and handling.

[2] Best Available Technology Not Entailing Excessive Costs (BATNEEC), formulated in the Environmental Protection Act 1990 and termed BAT in the Integrated Pollution Prevention and Control (IPPC) Council Directive (96/61/EC).

the necessity of the system, such as the changing composition of energy use (coal to gas, reducing SO_2 emissions without the need for further regulation); and a lack of support from industry and environmental groups. In addition, the constantly evolving nature of BATNEEC represented an uncertain trading environment. Steedman (1999) believes that the numerous European Directives largely explain why TP schemes are much more popular in the USA than in European countries. Therefore, TP schemes must be compatible with existing regulatory measures if they are to be successful. This problem was also evident in the Emissions Trading Programme established in the US in 1985. The value of emissions credits was uncertain as, if the state failed to meet its air quality target, credits would be confiscated, therefore discouraging the purchase of credits. This problem has since been resolved but serves as an important lesson for future schemes.

In preparation for the international emissions trading programme due to begin in 2008, the European Emissions Trading Scheme (EU ETS) was introduced across Europe in January 2005. The programme is established in the European Emissions Trading Directive and will serve as a 'trial and error' period and establish sufficient monitoring and enforcement programmes that can be adapted for the international programme before trading commences in 2008. The scheme will also "promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner" (DIRECTIVE 2003/87/EC) and will therefore contribute to achieving Europe's commitment to the Kyoto Protocol, a GHG emissions reduction of 8% below 1990 levels between 2008-12 (UNFCCC, 1992). Currently the scheme includes high emitting industries, such as cement and steel, and power stations from the 15 countries that made up the EU before the expansion to 25 countries in 2004. Phase I ends in 2007, with phase II beginning in 2008 – 2012, coinciding with the first Kyoto commitment period. For simplicity, the scheme currently includes only CO_2 emissions, with each permit being equal to one tonne of CO_2 or the equivalent amount of another gas based upon its Global Warming Potential (GWP). However, this will be extended to all GHG emissions in phase II when the international scheme will include trade of permits for six greenhouse gases[3]. Subsequent phases will run over 5 year periods. In order to establish caps on emissions, each country provided a National Allocation Plan, specifying the total amount of emissions permitted in phase I and how permits would be allocated. Governments were given the option of auctioning up to 5% of their national allocation, with the remainder being allocated free of charge on a grandfathering basis. Phase II will allow up to 10% of permits to be auctioned, with the remainder grandfathered. Those installations emitting more than their allocation must buy permits from the market, conversely those emitting less than their allocation benefit from selling their excess permits.

Due to the method of cap setting, the EU ETS is predicted to not realise its full potential during phase I. The National Allocation Plans (NAPs) reduced the effectiveness of the scheme, in terms of achieving the emissions target, as member states were authorised to produce their own NAPs and thus set their own standards. There is also an issue of fairness in this method, as industries within the scheme could have varying allocations depending on their NAP. In addition, this process is possibly open to pressure from industries on national governments, in terms of increasing their allocations. This highlights the need for strong political willpower, as also demonstrated by the underachievement of the full potential of the Zero Emissions Vehicle Program. Whilst the grandfathering approach is likely to incur high levels of political support, this method of permit allocation could also be problematic as it raises several fairness issues and discourages and possibly prevents new market entrants. However, the Commission have recognised the importance of over allocation and have subsequently set the NAPs for phase II to achieve a 7% reduction of emissions from 2005 levels (European Commission, 2006a).

This section of the review has revealed six key points that are essential to the success of any TP scheme:

[3] Carbon Dioxide, Methane, Nitrous Oxide, Hydroflourocarbons, Perflourocarbons, and Sulphur hexafluoride.

- The scheme must be compatible with existing regulations.
- The regulators must have a strong political will.
- All aspects of the system must be free of any uncertainty.
- The scheme must have enthusiastic support.
- The scheme must be necessary, and therefore its purpose is justifiable.
- The scheme must be effective by establishing limits and appropriate allocation methods.

2.5 Developments in TP schemes

Tradable permits are becoming increasingly popular amongst policy makers. For example, one of the emissions reduction measures outlined in the Kyoto Protocol is an international emissions trading programme, to become operational in 2008 (UNFCCC, 1992). Whilst the international trading scheme is a new concept, trading schemes have been used previously in order to satisfy the demands of a Protocol. For example, the Ozone-Depleting Substances programme was established in 1988 by the EPA as part of its implementation of the Montreal Protocol. The system was described as a success and provided flexibility in phasing out Ozone depleting chemicals (Harrison, 1999).

2.5.1 Political interest in the UK

There is a growing interest in the use of tradable permits to achieve emissions reductions in the UK. In addition to the desire to include aviation in the EU ETS, there is a strong interest in the use of personal carbon permits, where individuals are given a free allocation of permits and have the onus of reducing their own emissions. For example, the DEFRA recently commissioned a review of personal carbon trading (Roberts and Thumin, 2006), which investigated how such a scheme might work and highlighted the main knowledge gaps. The previous secretary for the environment, David Miliband, has also publicly discussed the idea of individual carbon trading (Adam and Batty, 2006). In addition, during a speech at the Audit Commission annual lecture, David Miliband highlighted several potential benefits of personal carbon trading (DEFRA, 2006c):

"It is easy to dismiss the idea as too complex administratively, too utopian or too much of a burden for citizens. Do we really want another Government IT programme? Are there not simpler ways of achieving the same objective by focusing on business to change their behaviour not citizens? And will it ever be politically acceptable? But, as the Tyndall Centre's work shows, in the long term, there may be potential to make a system work, and in a way that is arguably more equitable, more empowering and more effective than the traditional tools of information, tax, and regulation".

In addition, a report commissioned on the economic impacts of climate change discussed the application of tradable permits as a possible mitigation measure (Stern, 2006). Following the research conducted by Fleming (1996) and Starkey and Anderson (2005), a 10 minute bill on Domestic Tradable Quotas was presented by a Member of Parliament to the House of Commons in July 2004. There is also a growing interest in the use of TP schemes to reduce emissions from personal transport. For example, the Commission for Integrated Transport (CfIT) recently published a piece of research exploring the design of a TP scheme suitable for surface transport (Watters and Tight, 2007).

2.5.2 The EU ETS

Whilst the EU ETS does not currently include mobile emissions, the experience gained could be used to extend the scheme to include emitters such as vehicles (European Commission, 2003). In the EU ETS review, the European Commission focused on 2 options – including car manufacturers and including individual motorists (European Commission, 2006b). The UK government have also explored the prospect of including road transport in the EU ETS, concluding that the earliest date for inclusion would be during phase III in 2013 (DfT, 2007). In addition, the UK Government have declared their wish for aviation to be included in the EU ETS (DfT, 2003; DEFRA/DfT, 2007), which, if realised, could be a major step forward for the use of Tradable Permit schemes to reduce carbon emissions in the transport sector. Aviation was not included in the first phase of the programme, but the Commission is able to propose extending the activities covered by the scheme before the second phase begins in 2008. The UK Government is hoping to extend trading in aviation emissions to an international scale, however it is unknown when such a scheme will be established. The 33rd Assembly of the International Civil Aviation Organisation (ICAO) endorsed the development of an open emissions trading scheme for international aviation, although reaching a consensus amongst participants is likely to be a long process, therefore the UK Government are keen that aviation will be included in the European scheme until an international system is established (DfT, 2003). However, there is an issue regarding international flights in terms of fairness advantages gained by those airlines based outside of the EU. Including mobile emitters, such as cars would most suitably be done through the inclusion of fuel producers (upstream). Due to the substantial differences in buying power and demand for permits, it could be too problematic to include individuals in a scheme that also includes industry. However, the inclusion of fuel producers would essentially result in an additional cost on fuel price, which could incur low levels of public support. Such issues require consideration when evaluating the possible extension of the EU ETS.

2.6 Possible approaches to personal carbon trading

Within the literature, proposals have been developed for schemes designed to reduce national emissions of CO_2 from other sources of energy consumption in addition to that consumed for transport. The following sections describe and evaluate such schemes.

2.6.1 Domestic Tradable Quotas

The concept of Domestic Tradable Quotas (DTQs) was originally developed in 1996 by David Fleming (Fleming, 1996) and is also known as Tradable Energy Quotas (TEQs) (Fleming, 2007). The scheme is based on the concept of contraction and convergence, developed by the Global Commons Institute in 1990 (Meyer, 2000) and is designed to achieve a reduction in CO_2 emissions from domestic sources, including household energy and transportation. Fleming (2007) sets out two main reasons for applying TEQs: depleting oil supplies and the associated security issues, and the impacts of climate change. The scheme would be implemented at a national level with an annual limit placed upon the amount of carbon emitted from energy use. This 'carbon budget' could then be reduced each year in order to achieve the overall emissions target. It is proposed that the emissions limit would be set by an independent Carbon Policy Committee, thus being independent of central government politics. The carbon budget would be divided up into carbon units which would each equate to 1kg of CO_2. All fuels would be assigned a carbon rating, corresponding to the quantity of carbon emitted on combustion per unit of fuel and by the generation of a unit of electricity. As, at the time, roughly 40% of energy consumption in the UK resulted from domestic purposes, it was concluded that 40% of the annual budget would be allocated free of charge to adults on an equal per capita basis, and the remainder auctioned to organisations. Whenever individuals or organisations purchase fuel or electricity, they are required to surrender to the retailer the corresponding amount of carbon permits. There would be one emissions market, where the residential, industrial and commercial sectors trade together. Thus, adults consuming below their free allocation could sell their surplus permits back to the market, where they could then be purchased by adults consuming over their free allocation, or by organisations. However, this approach could be considered unfair by individuals as they have much lower buying power than organisations, thus leaving the latter at an unfair advantage in terms of purchasing permits. One approach would be to separate the market, for example, into personal and business permits, although by doing so this could reduce the overall economic efficiency of the scheme.

DTQs might be best monitored at the level of fuel producers, who would have to surrender carbon units corresponding to the amount of fuel sold. A computer data base would contain a carbon unit account for each individual and all transactions would be recorded. Each person would have an electronic swipe card which would have to be used, for example, when purchasing petrol. So far, research has revealed that such a database is feasible using current technology and could be linked to all fuelling stations in real-time, therefore allowing instant trading of carbon units. The carbon unit accounts have been proposed to be included on the national identity cards, should they be introduced (Starkey and Anderson, 2005).

Ongoing work carried out by Starkey and Anderson (2005) explores the use of DTQs and provides an evaluation in terms of equity, effectiveness and efficiency. Their findings suggest that there is enough evidence within the philosophical literature regarding distributive justice that an equal per capita permit allocation is equitable. In addition, if the revenue raised from permit sales is used appropriately, it should be possible to implement DTQs without disadvantaging those on low incomes. As individuals are given permits free of charge and on an equal per capita basis, this is likely to be considered as the fairest approach and would thus maximise public acceptability of the scheme. With the establishment of a fixed annual carbon budget in line with an overall emissions target, DTQ schemes should be effective in terms of achieving the emission reduction target. In addition, the use of existing credit card technologies is well understood and has been operational for a number of years. Thus, the scheme should be technologically feasible. Given that costs are likely not to exceed those relating to other government IT projects, DTQs could be affordable in public policy terms. In addition, the efficiency of DTQs is further increased as individuals would be incentivised to identify ways to reduce emissions and benefit from selling excess permits or from buying less, thus leading to more efficient emissions reduction (Starkey and Anderson, 2005).

2.6.2 Personal Carbon Allowances

Hillman and Fawcett (2004) propose a mandatory system of personal carbon allowances (PCA) to significantly reduce carbon emissions in the UK. This has been further developed by Fawcett (2005). Based on the principle of contraction and convergence, the PCA scheme uses a very similar structure to the DTQs scheme. However, the fundamental difference is the scope of the scheme as PCAs regulate emissions arising from personal energy use only, whereas DTQs cover all national emissions sources, thus organisations and individuals. The scheme would have an overall emissions target, for example, in order to stabilise atmospheric levels of CO_2 at 550ppm, a 60% reduction of CO_2 emissions would be required by 2050. There would be a limit on the amount of carbon available each year, with this carbon budget being reduced each year in line with the overall emissions reduction target. The PCA scheme would include all personal domestic energy consumption, thus including personal transport. In the UK, personal energy consumption accounts for over 50% of the total energy consumed. Each adult would receive an equal amount of the annual carbon budget in the form of personal carbon allowances (PCAs). Children would receive a smaller allocation as they would typically require less than adults. Rather than allocate additional permits to groups that could be largely disadvantaged by the scheme, Fawcett (2005) proposes government subsidies for energy efficiency and/or renewable energy measures for certain classes of people. This method is preferred as it is recognised that by providing certain groups with more PCAs results in a reduced ration available for everyone else. The equal per capita allocation of PCAs is justified in terms of equity, where everyone is provided with equal rights to pollute. The allowances would be tradable, thus those that have excess allocations and those who are able to reduce their emissions can benefit by selling their excesses to those consuming over their assigned amount. The tradability of allocations increases the economic efficiency of the scheme as emissions are being reduced at the least overall cost.

The PCAs would be administered using individual electronic cards that would contain the full annual allocation. It is proposed that existing technology could be used, thus reducing implementation costs. The scheme would be introduced with as much information available as possible regarding the carbon impacts of everyday decisions. Suggestions include: smart utility bills showing carbon emissions in addition to monetary costs; enhanced fuel pumps displaying the carbon content of the purchase; carbon-ometers in vehicles to record carbon emissions; carbon labels on appliances; and carbon rated homes sold with an energy survey. Fawcett (2005) recognises that one of the key benefits of carbon rationing is the provision of a framework for carbon reductions. There is no need to promote separate polices, such as cycling strategies, as individuals would recognise the benefits of energy reduction measures such as renewable energy sources, household energy efficiency improvements and low carbon methods of transport. The scheme also provides personal flexibility in energy reduction as people can choose the most feasible method. Whilst carbon rationing places responsibility for carbon reductions on the individual, this in turn creates a demand for products and technologies with improved energy efficiency, thus creating a competition between manufacturers to sell low carbon products. This process has the extra benefit of making manufacturing processes and products more energy efficient without the need for regulation.

2.6.3 Compatibility with existing measures/more extensive trading

Section 2.4 revealed the importance of trading schemes fitting in with the current policy landscape, which was also noted by Bottrill (2006) and Roberts and Thumin (2006) in regard to personal carbon trading. The following section therefore explores the compatibility and integration of the national measures discussed above (DTQs and PCAs) with the EU ETS.

Table 2.1: Compatibility of DTQs and PCAs with the EU ETS

Emissions source	EU ETS		DTQs		PCAs	
	Org	Ind	Org	Ind	Org	Ind
Stationary emitters:						
Electricity	✓	x	x	✓	x	✓
High-emitting industrial	✓	x	✓	x	x	x
Others	x	x	✓	✓	x	x
Mobile emitters:						
Road	x	x	✓	✓	x	✓
Air	x	x	✓	✓	x	✓
Other	x	x	✓	✓	x	✓

Key: x = not included, ✓ = included. Org = organisation, Ind = individual. Adapted from Starkey and Anderson (2005).

Given that all schemes employ carbon permits as the trading commodity, it is feasible to explore the possibility of integration. Starkey and Anderson (2005) suggest a route from the EU ETS to a DTQs scheme. As the EU ETS includes emissions from the electricity sector and large industries, and DTQs includes all emitters other than the electricity sector, the EU ETS could be gradually expanded to include more emitters and finally, individuals. To avoid double counting, it would be necessary to change the entities that surrender permits in the electricity sector from the power stations to the end purchasers (individuals). A similar evolutionary route could be imagined in terms of combining the EU ETS with PCAs. Individuals would surrender permits for their electricity consumption, whilst the EU ETS expanded to include other emitters and individuals. However, there are several issues to highlight when considering the evolution of a national trading scheme to an international scale. Individual countries, for example the UK, could possibly lose the authority to set their own caps, as foreseeably the scheme would be administered and monitored at an EU level. In addition, the complexity of trading between individuals at an EU level has not been investigated although it is foreseeable that the complexities involved in monitoring could be magnified in comparison to those expected in a national scheme. Integration would thus be dependant on the adequacy of monitoring and the technological feasibility of administering a database at an EU level.

2.7 Reducing CO_2 emissions from the personal transport sector through the application of tradable permits: up stream and downstream approaches

Within the transport sector, trading of CO_2 emissions permits could take place amongst individuals or companies. The latter option could include fuel suppliers and vehicle manufacturers and is referred to as an 'upstream' scheme. A scheme where individuals are the trading entity is referred to as a 'downstream' scheme (Roberts and Thumin, 2006). The following section discusses several possible designs for both types of schemes within the transport sector.

2.7.1 Tradable Fuel Permits

Dobes (1997) suggests allocating Tradable Fuel Permits (TFP) to individuals, primarily because it would provide a direct incentive to reduce fuel consumption through vehicle choice, driving behaviour and residential location. Another benefit would be the creation of a large market due to a large number of players, which would increase the efficiency of the system. However, the major drawbacks that Dobes (1997) perceives to inhibit implementation of such a scheme are the substantial implementation, administration, monitoring and enforcement costs incurred. Whilst the costs involved may be substantial, it could be possible to auction permits in order to raise the revenue required. Therefore, the monetary requirements of TP schemes designed to regulate mobile transport emissions may not be such an inhibiting factor.

Keppens and Vereeck (2003), also discuss a TFP scheme applied to individuals. The scheme would be used in order to meet an emissions reduction target in line with the European Kyoto Protocol targets and would thus be implemented throughout the European member states. The TFP scheme is proposed to begin operation in 2008, with the aim of reducing total CO_2 emissions from passenger cars by 8% (404 million tonnes of CO_2 to 372 million tonnes of CO_2). The cap during the first year of implementation would be set at total CO_2 emissions from passenger cars in 2007, and then be reduced each year to the target level. Each TFP would accord to one kilogram of gasoline, the amount of fuel would change depending upon fuel type and its carbon content. An electronic swipe card would be required to purchase fuel and each transaction would be recorded in order to aid monitoring and enforcement of the system. The TFPs would be distributed free of charge amongst the population, the amount received depending upon age: 0-18 years (youngsters), 18-65 (active), and 65+ (retired). Whilst this allocation method may be plausible in an obvious sense, for example, that a person aged 6 years will not require as many permits as a person aged 25, such categorisation could be construed as age discrimination. It is also unfair as it is plausible that a person aged 17 could require as many permits as someone aged 30 years but would have to pay more to obtain them.

The TFPs would be distributed at the beginning of each year, which offers a convenient administrative mechanism for monitoring. In order to reduce costs, monitoring would be carried out upstream upon fuel producers and importers. TFPs would have to be presented in proportion to the amount of fuel sold. Such a mechanism would reduce costs as fewer parties require monitoring (in comparison to each individual permit holder being monitored). One of the perceived problems of such a scheme is avoidance behaviour, which would be highlighted on a continent (compared to an isolated state) if it were possible to cross the border in order to refuel in a country that was not participating in the TFP scheme. Such problems are possible in Europe and Keppens and Vereeck (2003) suggest that all outgoing transport be forced to refuel before crossing the border. However, the likelihood of being able to impose such a requirement is unknown. A European institution would be formed and would be given authority to monitor member states and enforce penalty payments for any infringement of the rules. Keppens and Vereeck (2003) state that this is essential as each member state would then have direct incentives to adequately monitor and enforce national TFP schemes, thus making the scheme more efficient.

Verhoef *et al* (1997, p. 547) believe that "there seems to be sufficient room for using tradable permits in the regulation of road transport externalities" and describe a TFP scheme for individuals, but rather as part of a package of instruments than a sole measure as suggested by Dobes (1997), and Keppens and Vereeck (2003). The TFP is proposed as the most attractive option for the regulation of non-localised and time independent external costs, such as CO_2 emissions, whilst tradable road pricing smart cards are suggested as a control measure for localised and time-dependant externalities, such as congestion and local air pollution. However, the focus here will be upon the TFP scheme as it would affect all externalities, irrelevant of time and location. For example, fuel users would be inclined to optimise their fuel usage and thus waiting in congested conditions where an engine would use fuel inefficiently is likely to be avoided where possible. In addition, the combustion of fossil fuel is the primary cause of local air pollution, thus a focus upon reducing the amount used would lower pollution levels. It is also unlikely that the two systems would be implemented together, or at all, considering the increased costs involved in applying two schemes rather than one. Verhoef *et al* (1997) state that TFPs are the most promising direction for the use of tradable permits in the regulation of road transport externalities and recognise the benefits of a TFP scheme, being the provision of incentives to reduce car use and purchase energy-efficient vehicles, and overall a reduction in road transport externalities. No major obstacles are envisaged in terms of monitoring and enforcement mechanisms, providing that permits are required to purchase fuel. A proposed solution to border problems, as also noted by Keppens and Vereeck (2003), would be to gradually decrease the amount of permits required for fuel purchase 50km from the border until the border is reached. This method is envisaged to discourage individuals crossing the border to re-fuel. However, it would have several impacts: individuals would have an incentive to travel to the 50km zone where more fuel could be obtained with less permits, creating in effect a traffic generator; also, individuals residing within the area would benefit from higher fuel consumption in comparison to a person who has an equal number of permits residing too far away to warrant travelling the distance, thus raising an equity issue.

In recognition of the significance of, and the threat posed by forecast increases in, GHG emissions from the transport sector, a working group of the National Transportation Council in France have explored potential applications of tradable permits (Raux, 2002). The group also wanted to find ways of escaping the 'environmental deadlock', which they perceive as conventional instruments, such as fuel taxation, that have reached their limits. The fuel tax protests that occurred in the UK during September 2000 is the example used to highlight such limits. They describe a TFP scheme distributed downstream, where each vehicle would receive an equal amount of permits. However, there are obvious drawbacks to this approach. Individuals who owned more than one car would have advantages over those who did not, such as the ability to consume more travel or profit from selling excess permits. This could provide incentives to purchase extra vehicles, perhaps older and very fuel inefficient models, in order to gain the benefits outlined above. These issues are very important aspects that require consideration in such a proposal. The benefits recognised by the group was the incentive to optimise individual travel, as also recognised in all of the proposals discussed above. Again, the perceived drawbacks are the introduction and monitoring costs.

2.7.2 Voluntary Tradable Fuel Permits with taxation

Raux and Marlot (2005) believe that, due to the impending development of stringent objectives regarding emissions reduction, a fuel ration seems unavoidable. They describe how a system of decentralised transferable permits could work, using the case of France as an example for practical application. Raux and Marlot (2005) preferred a downstream scheme because an upstream scheme would lose its advantages over a tax system as there would be no permit allocations and possible acceptability issues could arise as a result of allowing private companies to manage the rationing.

Their proposal is a system of TPs that relate to fuel consumption at the individual level. Permits corresponding to the amount of CO_2 contained in the fuel would be transferred at the point of sale. To reduce problems of social and political acceptability, permits would be freely allocated to individuals based on their possession and use of a car. This could possibly encourage those who do not own cars to purchase one and join the market, or encourage multiple ownership. However, Raux and Marlot (2005) highlight the limitations of doing so, as a result of the vehicle insurance and maintenance costs. The amount of permits allocated to each person would be based on the average consumption of fuel per vehicle. The authors also suggest, to avoid the occurrence of equity issues, an allocation method based on socioeconomic characteristics could be applied where, for example, families with children and those living in rural areas are given more permits. However, this could raise fairness issues amongst those that have no children but do an equal amount of travelling. Thus, the most viable allocation of permits appears to be an equal per capita approach, where each person would receive an equal amount of permits regardless of their personal choices or circumstances.

One of the main benefits regarding the free permit allocation is that a certain amount of fuel can be consumed without incurring any additional costs, thus having equity and accessibility advantages over a tax system (Raux and Marlot, 2005), though it should be noted that a tax system could be set up to replicate this to some extent although the process of revenue redistribution would arguably be more complex. The regulating authority would introduce and publicise a regular reduction in permit availability, with a rolling horizon of around a decade. Permits would remain valid for an unlimited period, although any unused permits would be taken into account when establishing the free allocation of permits the following year. Permit exchange would be centralised through a stock exchange, which would yield the daily permit value. Sales and purchases could also be made at banks or using the internet. Each person would have a permit account held on a chip card which would record debit and credit operations. This card would be compatible with existing automatic teller machines already installed at fuel stations. The use of existing technology would therefore reduce implementation costs.

Raux and Marlot (2005) propose that the TP scheme be introduced with a coinciding CO_2 tax, assuming it would be socially unacceptable to suddenly apply the permit scheme to all motorists. The permit scheme would then be a voluntary measure which motorists could opt into, with the benefit of receiving a free permit allocation and thus avoiding the CO_2 tax until the allocation has been used. Thus, opting into the permit scheme would actually be a less costly option then simply paying the CO_2 tax. To maintain this benefit, the maximum permit price would not increase beyond the level of taxation. Thus, the price of permits is bounded by the level of tax. Raux and Marlot conducted a quantitative evaluation of both measures to conclude that the main difference between the two options results from the transfers between motorists and central government. Using an elasticity of fuel demand of -0.3, in the case of tax they calculated that motorists as a group would lose approximately €7.2 billion, and central government would gain almost €5.1 billion. In the long run, applying an elasticity of -0.7, these values become €3 billion and €1.2 billion respectively. In the case of permits, the transfers are significantly lower as a result of the free permit allocation. For the two elasticity values (-0.3 and -0.7), the losses to motorists would be €374 million and €161 million respectively. This demonstrates that, as a group, motorists would be less worse off under a system of permits rather than tax. The dramatic difference would be experienced by central government, which, due to the reduction in fuel consumption and thus tax revenue, would loose more than €1.7 billion. However, as this loss could be reduced if, for example, only 50% of the permits available were distributed at no charge, with the reminder being priced at cost to offset losses in tax revenue. This method could possibly reduce the occurrence of a political versus public acceptability debate which could arise given the option of adopting a system where all permits are free, and thus maximizing public acceptability, or a system where there are no free permits, thus minimising loss of government revenue but incurring lower levels of public support.

Raux and Marlot (2005) suggest that the permit market be operated openly, thus allowing the exchange of permits between all emitters of CO_2 across various sectors. Such a market would include freight and public transport, however, due to the international competition between carriers, it is recognised that these modes would need to be included in a scheme operational at the EU level, or higher.

In conclusion, Raux and Marlot (2005) recognise that the tax system has advantages in terms of the lower implementation costs and governmental revenue losses. However, the benefits of a permit scheme are considered to far outweigh such advantages, considering the higher levels of public support resulting from the free permit allocation, the strong incentives to reduce consumption in terms of benefits received, greater certainty of achieving the emissions reduction target and the possibility of linking the permit scheme with a global market whilst allowing central government complete control over the domestic market, thus having the ability to protect it from fluctuations on the world market.

2.7.3 Trading schemes amongst fuel producers

A study commissioned by the Swedish Environmental Protection Agency (SEPA) (SEPA, 2006) describes the options available for reducing CO_2 emissions from road transport. Following a review, they recommend further exploration of a cap and trade scheme amongst fuel suppliers and a baseline and credit scheme for car manufacturers, believing that it would improve the cost effectiveness of CO_2 mitigation. This upstream approach is preferred to a downstream scheme amongst individuals as the latter is considered to be more difficult to monitor and enforce. In addition, the large number of trading entities involved would lead to high transaction costs, with only limited benefits in terms of efficiency or effects on competitiveness compared to a scheme based on fuel suppliers. Instead the upstream scheme amongst fuel suppliers is preferable as it is, in principle, feasible to include all transport modes (e.g., freight, shipping, air and cars/vans), although it is recognised that this would require a lot of work on improvements in data monitoring, policy design and implementation. A step by step approach is thus recommended, where the scheme would first be implemented for one or more modes, such as road transport, then extended to include other modes at a later stage. In order to steer emissions reduction in the transport sector, SEPA recommend a closed system with an established cap on emissions.

SEPA (2006) also recommend the further exploration of a CO_2 tax on fuel as an alternative policy, noting that it would provide similar effects as a cap and trade scheme for fuel suppliers whilst being easier and less costly to implement. However, there are other important considerations to be made here, such as the effectiveness (ability to meet the emissions reduction target) and public acceptability.

Grayling *et al* (2006) propose an extension of the EU ETS to include tailpipe emissions of CO_2 from road transport, indirectly through fuel suppliers. Due to the small number of companies involved (20 in the UK account for more than 99% of fuel used by road transport), and with the fuel duty system already in place accounting for every litre of fuel supplied, such a scheme would be relatively simple and cheap to administer. If within the UK, the scheme would be administered by the Environment Agency and, based on the costs of the Renewable Transport Fuel Obligation (a tradable obligation on fuel suppliers to supply bio fuels), is estimated to cost around £1 million per year for the government and £2 million per year for the industry, which is a very small proportion of their annual turnover. Currently the EU ETS does not include mobile sources of CO_2, but the possibility of expansion to cover such sources is included in the legal framework (Article 24). If extended to an EU level, currently there are 102 oil refineries owned by 31 companies, while each country has a system of fuel duty, thus providing the administrative foundation. As a result, the administration of the scheme is thought to be straightforward and cost effective.

Emissions allowances could be allocated to fuel suppliers at a national or EU level. However, given the inclusion of international aviation and the fact that the oil industry operates internationally, the authors suggest a more logical approach would be to allocate at the EU level. Permits would be allocated free of charge, either based on market share (grandfathering) or through auctioning, or a combination of these methods. One option would be to auction all of the permits available, using the revenue to reduce fuel duty, thus demonstrating that the scheme is designed to reduce emissions rather than raise revenue. However, in doing so, this could lead to an increase in demand for fuel, and hence the increased possibility of shortages. Another option would be to earmark a proportion of the revenue for climate change mitigation measures, which is likely to be less problematic than reducing fuel duty.

Emissions permits would be tradable between suppliers, thus providing incentives to produce cleaner fuel supplies. Allowances corresponding to the amount of fuel supplied, in terms of CO_2 equivalent, would be surrendered each year. As their carbon content is renewable, bio fuels would be exempt. This provides a double incentive, firstly the fuel suppliers require less permits if their sales of bio fuels increases and secondly, the increase in demand for bio fuels is likely to increase as it would be sold at no extra charge in comparison to diesel or petrol. This creates a positive feedback process between individuals and fuel suppliers, with the overall impact being to increase the consumption of bio fuels and reduce the consumption of other fuels. However, this does not take into account the sustainability issues regarding bio fuels in terms of land requirements, deforestation and transportation from the country of production to the country of sale.

An upstream scheme amongst fuel suppliers is preferred to a scheme amongst individuals due to the political barriers, the administrative costs and the complexity of involving individual car owners in the EU ETS. People would have to learn how to use the scheme, which involves understanding carbon emissions as a new currency. In addition, large numbers of people are likely to require extra emissions allowances to continue their current behaviour or be forced to change their behaviour, which could result in low public support for the scheme. It is recognised that in the long term, none of the aforementioned barriers may be insurmountable, however the inclusion of households in the EU ETS is unlikely to be a politically viable option for phase III (beginning in 2013-2017). Many of these points are also applicable to a scheme amongst fuel suppliers. It is already problematic to ascertain a fuel price across Europe (SEPA, 2006; Raux and Marlot, 2005), thus agreeing permit allocations and prices has the potential to be equally as problematic. Moreover, under a cap and trade scheme, unless the environmental performance of fuel improved in line with the cap, the amount of fuel available would decline, for example, each year if linear annual reductions were imposed. Thus, it would be impossible for individuals to continue their current behaviour without either increasing their expenditure on fuel or purchasing a much cleaner vehicle. Therefore, some level of involuntary behavioural change seems inevitable as a result of either an upstream scheme amongst fuel suppliers or a downstream scheme amongst individuals. In addition, the scheme proposed by Grayling *et al* (2006), could be difficult to sell to the public as an environmental measure, instead being viewed as an additional fuel tax and another government fund raiser, as essentially, the impact on end users would be the same as a tax increase (increased fuel price). The strong objections to the fuel tax escalator demonstrated in September 2000 in the UK provide evidence of the limited public support for fuel price increases (Lyons et al., 2002). To avoid similar events, it would be necessary, through information campaigns, to make the public fully aware of the aim of the scheme, how it would work, how it would be monitored and why it is preferred to the alternatives, for example, people would not have the inconvenience of having a permit account with the need to exchange permits in addition to money when purchasing fuel. However, many people might see the other side to this argument: those that reduce their consumption could have permits to sell and thus profit from, whereas reducing consumption in an upstream scheme would provide no such incentive.

2.7.4 Trading amongst vehicle manufacturers

In response to a critical analysis of the ACEAs voluntary agreement designed to reduce CO_2 emissions from new vehicles, Michaelis and Zerle (2006) instead propose a baseline and credit trading scheme amongst vehicle manufacturers. This approach is preferred to an upstream scheme based on fuel consumption as this is believed to act as an additional tax, thus being unacceptable to consumers and is believed to not fully exploit the potential for increasing energy efficiency of vehicle technology. However, this could be achieved indirectly by stimulating consumer demand for cleaner vehicles and fuel in response to high fuel prices and limited availability. This approach would not require regulation amongst vehicle manufacturers and could thus be more politically acceptable.

The aim of the trading scheme would be to achieve a CO_2 emissions target for passenger cars placed on the EU market within a given trading period. Each car manufacturer would be required to buy an amount of permits equal to the estimated amount of CO_2 emissions caused by the vehicles sold within the given trading period. By gradually reducing the amount of permits available, a set reduction in aggregate annual fleet emissions would be achieved across all car manufacturers. In addition, the tradability of the permits allows the greatest improvements to be made at lowest cost.

The scheme would be a supplement to the existing fuel tax system, thus overall targeting drivers and influencing their driving habits through the tax and influencing fuel consumption and CO_2 emissions from passenger cars through the permit scheme. However, it could be argued that a downstream carbon trading scheme amongst individuals alone could achieve this, thus requiring only one form of regulation with the possibility of achieving greater levels of political support.

Vehicle manufacturers could achieve reductions in three main ways: developing new technologies, reducing the size of vehicles, and marketing to promote the sale of such low emissions vehicles. The latter option is thought to have a greater impact over time due to the influence that marketing strategies are currently thought to exert on consumer attitudes and choice.

2.8 Strengths and weaknesses: evaluating the options for TP schemes in the transport sector

This section discusses the key strengths and weaknesses of the different approaches to reducing CO_2 emissions from personal transport through the application of tradable permits. Each approach was evaluated according to its scope and design attributes.

2.8.1 TFPs: upstream

Due to the relatively small number of trading entities, a trading scheme amongst fuel producers would be much easier to implement and monitor than a downstream scheme amongst individuals, whilst also having the ability to achieve the same emissions target due to the cap on fuel availability. However, the impact on consumers would be an increased fuel price with the knowledge that fuel availability is limited. Given the public dislike of increased fuel prices, this approach could be highly unacceptable. In addition, the impact on individuals could be similar to a fuel tax, which could have regressive effects, i.e. many losers (particularly those on low incomes). As a result, it would be necessary to provide compensation in the form of redistribution of benefits, which are likely to be in the form of tax relief elsewhere, for example, income. It would be much easier to include fuel producers, rather than individuals, into the EU ETS, as it is currently an upstream system. However, it is possible that the limits on availability would not be as strong in an upstream scheme as individuals are not directly involved in terms of having a permit allocation. Hence, it is possible that the risk of permit shortages or very high permit prices would be more likely to occur in an upstream design. There could potentially be an issue of political acceptability amongst fuel suppliers in an upstream scheme. For example, in the UK, only 20 companies supply fuel (Grayling *et al.*, 2006). As the UK is dependant on fuel supplies from such companies, it could be difficult to enforce any scheme that could have adverse affects on profits amongst an industry that could have substantial lobbying power. In addition, as highlighted in section 2.4, a strong political will to enforce the scheme would be essential.

2.8.2 TFPs: downstream

A downstream scheme is likely to result in fewer inequities than an upstream scheme, as individuals have the option of trading and benefiting from selling excess permits. A free allocation would also provide a certain amount of fuel to be purchased at no additional costs, thus reducing the regressive impacts in comparison to an upstream scheme where individuals have no permit allocation. The distribution of permits also provides an incentive to reduce fuel consumption and thus sell excess permits. An equal per capita allocation method that applies to everyone regardless of car ownership would have the effect of providing monetary compensation to those that do not purchase fuel. In addition, this approach is likely to be considered as the most fair method, as everyone would receive the same amount of permits. Thus, this approach is likely to attain greater levels of public support than a system based upstream amongst fuel producers. Conversely, the upstream scheme could be preferable in that permits are not required to purchase fuel, thus removing the inconvenience of having to purchase permits.

There are potential issues regarding the implementation costs of a downstream scheme, given the large number of trading entities involved and the level of monitoring required. However, such costs can be largely, if not fully, offset by auctioning a proportion of the annual carbon budget.

2.8.3 Vehicle manufacturers

It is likely that the only acceptable method of permit allocation would be the grandfathering approach, as this allows gradual adjustment from current emissions levels, whereas a baseline and credit scheme would require the purchase of additional permits if a reduction was not made over the compliance period. However, there are issues with both approaches as they discourage new market entrants and favour those organisations that have relatively higher levels of emissions as they would receive a larger initial allocation than a smaller emitter. This could create additional issues of fairness, and thus unacceptability amongst those involved.

The appropriateness of a scheme amongst vehicle manufacturers is dependant upon the target to be reached. For example, if the target is to reduce CO_2 emissions from the transport sector by 60% by 2050, the use of an upstream scheme amongst fuel suppliers or downstream scheme amongst individuals would be better equipped to achieve the target, given the ability to place a cap on carbon availability. In addition, a scheme amongst vehicle manufacturers could not influence the level of vehicle usage, and thus the amount of emissions arising from vehicle use. Moreover, the monetary costs per kilometre travelled would decrease which could subsequently result in an increase in vehicle kilometres and thus traffic volumes. A TFP scheme could possibly stimulate vehicle manufacturers to increase fuel efficiency as there would be a demand resulting from individuals wanting to get the most out of their TFPs in terms of personal travel. Hence, the same or similar results could be achieved through a TFP scheme without the need for additional regulation amongst vehicle manufacturers. A scheme amongst vehicle manufacturers could only be effective when applied to reducing fleet emissions, i.e., grams of CO_2/kilometre, rather than reducing CO_2 emissions across the transport sector to a predetermined level.

Section 2.4 highlighted the need for a strong political will in order to make a TP scheme successful. To date, the European Union have a voluntary agreement with vehicle manufacturers, hence it is highly possible that changing the nature of regulation from voluntary to mandatory could be unacceptable amongst vehicle manufactures.

2.9 Public support for TP schemes in the transport sector

Section 2.8 identified a downstream TP scheme to possibly be more acceptable than an upstream design, largely as a result of the perceived difference in equity impacts. Given the importance of acceptability when deciding whether a policy will become operational (Whittles, 2003; Schade and Schlag, 2003; Jones, 1995; 2003), this section further examines the issues that could possibly influence the acceptability of a downstream scheme of tradable permits in the transport sector. For the purpose of the following evaluation, it is assumed that each individual would receive a free allocation of permits on an equal per capita basis with a predefined cap on carbon availability.

2.9.1 Effectiveness

Several studies have revealed that acceptability of a road pricing measure (used as a generic term to describe any measure that imposes increased costs on consumers), is largely dependant upon the ability to meet its aim (Schade and Schlag, 2003; Rienstra *et al.*, 1999; Jones, 2003; Whittles, 2003). A TP scheme could, theoretically, be 100% effective as a quantitative approach is used, being a limit placed upon carbon availability within a specified time period. Therefore, regardless to individuals' willingness to absorb additional costs, the emissions reduction target would be obtainable as consumption could not go beyond the set carbon allowance.

2.9.2 Benefits

Benefits received as an outcome of a pricing measure are fundamental to acceptance (Jaensirisak *et al.,* 2003; Schade and Schlag, 2003). The benefits that could potentially arise from a TP scheme are essentially the same as those arising from pricing measures such as fuel price increases. For example, both measures could result in a reduction of car use and thus subsequent reductions in local air and noise pollution, traffic congestion and road accidents (see section 10 for further details on benefits). However, the realisation of such benefits is dependant upon the ability to achieve the emissions reduction target. As a TP scheme is potentially a very effective measure, it could thus be considered acceptable. Benefits exclusive to the TP scheme would be the direct financial benefits from selling excess permits. Therefore, individuals are provided with positive incentives not to pollute, rather than not being able to pollute due to financial restrictions which may occur in a fuel price policy and may thus be viewed as less positive.

2.9.3 Fairness

Acceptability is strongly connected to fairness (Rietveld and Verhoef, 1998; Viegas, 2001; Jakobsson *et al.*, 2000; Fujji *et al.*, 2004; Erikson, 2006; Bonsall, 2007). Issues relating to infringement of freedom and exclusion from activities are prevalent objections to pricing measures. In addition, extra charges may be considered as punitive and unfair as prices will be paid regardless due to the inelasticity of car use. Raux (2002) perceives rationing the right to freedom of movement to be one of the main public objections to the introduction of a TP scheme. However, with any pricing measure, some degree of unfairness is inevitable due to the unequal distribution of resources throughout society. As also noted by Steg (2003), it is very difficult to fairly distribute amongst the public the pains and gains of transport pricing. However, the key is to minimise inequities, or keep them to a minimum (May, 1992). A TP scheme could potentially minimise inequities on the basis that each person would receive an equal amount of permits free of charge (in comparison to each person having to pay the same increased price for fuel immediately following the increase).

2.10 Perceived benefits of a downstream TP scheme in the transport sector

Many significant benefits could arise from the implementation of a successful TP scheme. Table 2.2 provides a range of possible benefits that a successful trading scheme might provide and outlines the main beneficiaries. In most cases, society would be the main beneficiary and in many cases this would benefit the government in terms of retaining revenue that would otherwise be required. It should be noted that some or all of these benefits could possibly be obtained through other measures to reduce carbon emissions, such as fuel price increases, depending on the level of effectiveness in terms of achieving the desired targets.

Table 2.2: Potential benefits and beneficiaries of a successful TP scheme

Benefit	Beneficiary
Reduced impacts of climate change	Natural and human systems
Reduced local air pollution	Society, government
Reduced congestion	Society, government
Increased trend towards localisation	Society, local economies
Improved health and fitness	Society, NHS
Enhanced community spirit	Society
Increased use of public transport	Public transport operators, society
Increased uptake of clean fuels and vehicles	Industry, society

The main benefit of a successful TP scheme designed to significantly reduce carbon emissions could be the reduced impacts of climate change, which is an international benefit. However, the overall impact on climate change mitigation would be dependant on global participation (Hillman and Fawcett, 2004), given that the UK currently contributes 2% to global emissions (DEFRA, 2006a), of which transport accounts for approximately 26% (DfT, 2006a). As outlined in chapter 1, climate change is expected to have a range of negative impacts. As the benefits of reducing these impacts would be at an international level, from this perspective it would be in the interest of all nations to join or establish an emissions trading scheme. In addition, a recent report by Stern (2006) suggests that the result of taking no action against climate change would cost around 5% of global GDP each year, whereas the cost of taking action would be much less at around 1% per year. Thus, the impact of climate change on the global economy could also be significantly reduced.

Whilst the relationship between carbon emissions and local air pollution is indirect, it is possible to assume that, as a result of a reduction in the use of petroleum, more efficient driving practices and/or increased use of clean fuel technology, all emissions created as a result of transportation would decrease in quantity. Congestion levels are likely to decline as a result of the TP scheme (people may avoid congestion in an effort to reduce fuel consumption), thus accumulation of pollution in congested zones would decline. In addition, a reduction in congestion creates a time benefit for the public and a significant monetary benefit to the economy, given the estimated cost of traffic congestion in the UK, which is currently £20 billion each year (Cook, 2005).

Given the health impacts associated with local air pollutants (COMEAP, 1998), health benefits can also be assumed to result from a reduction in the emission of local air pollutants. In addition to providing a public health benefit, this in turn would reduce the demand for the National Health Service. There would also be an environmental benefit in terms of reducing acid rain formation and in turn reducing the impact on vulnerable ecosystems. However, it would be difficult to determine a precise reduction in local air pollutants as the amount of emissions is dependant upon engine performance, which depends upon driving behaviour and driving conditions (i.e. number of engine revolutions and temperature).

A TP scheme could also create a demand for local amenities, as this would reduce the need for car use and/or reduce journey length. The provision of local amenities would also encourage the use of alternative modes such as walking and cycling, as car use may be unnecessary. Thus, another health benefit would result, in terms of increased levels of physical fitness. The economic gains from selling permits could provide an important source of income to those in lower income quintiles and help to improve living standards and quality of life. Individuals would be forced to make decisions regarding their travel behaviour which may help to promote an increased sense of responsibility for personal actions and environmental consciousness. A major perceived outcome of the system would be a move away from car dependency and high travel consumption. This in turn would provide an increase in quality of life as a result of reduced levels of air and noise pollution, increase in physical activity (cycling or walking rather than driving), and increased leisure time (less time spent in congested traffic and travelling). An increase in socialisation may also be expected due to the use of local facilities and services, increase in car occupancy, and trading routes.

If abatement costs are lower than market prices, or if changes are viable, it is likely that those individuals that are able to alter their travel behaviour will do so, either to cooperate with the scheme or to benefit from selling excess permits. It is possible that in order to maintain car use, modes that consume less carbon would be used, such as public transport. As a result, it is likely that the provision of public transport would need to be increased substantially in order to provide alternative travel modes to car use. The use of public transport would be even more attractive if, for example, individuals did not require permits to use such modes, but did require permits to purchase fuel for car use. The main beneficiaries would be the operators, as a result of the business opportunities, and thus increased profit, that would be created. In addition, the increased use of public transport could improve social cohesion by re-establishing or creating an increased sense of community spirit as people would be travelling together rather than separately, thus creating an opportunity to socialise.

The purchase of clean fuel technology (fuel and vehicles) could dramatically increase, such as hybrid, fuel cell or electric vehicles, which would require less alteration to personal travel behaviour. The main beneficiaries would be the fuel producers and vehicle manufacturers, in terms of business expansion and thus increased profits. In addition, the increased up take of clean fuel technology could lead to mass production and thus reduced retail prices, leading to further uptake as it becomes affordable and eventually creating a positive feedback cycle until prices are as low as possible. It is also possible that travel distance will be reduced, with individuals living closer to places of employment or using local amenities. Frequency of journeys is also likely to be reduced, which would be aided by the provision of local amenities; trip-chaining; and working from home where possible. Where possible, individuals would benefit from increased vehicle occupancy, thus car-sharing activities could increase.

Motorists would be inclined to drive in a manner that utilises fuel most efficiently, thus for example, avoiding rapid acceleration and deceleration and excessive speed. Keppens and Vereeck (2003) suggest that as high speeds would be avoided, an improvement in road safety could be expected. However, the opposite effect could also occur where drivers exceed speed limits in order to maximise fuel efficiency (e.g. in a 20 mph zone). Therefore, it is possible that a TP scheme may require more stringent penalties placed upon speeding offences.

Whilst a number of suggestions are provided here, the real benefits and social impacts, and thus the social feasibility of a TP scheme, are largely unknown. Thus, further research in this area is of paramount importance to the progression of tradable permits in the transport sector.

2.11 Carbon tax on fuel as an alternative measure

Whilst the aim of the review was to explore the potential of tradable permits, it is important to simultaneously explore the alternative measures in order to determine the most suitable policy. TP schemes were identified as having the potential to be 100% effective, however increasing fuel tax could arguably deliver the same or similar reductions. According to elasticities of fuel demand, fuel tax could be designed to achieve significant reductions in CO_2 emissions from the transport sector. Further advantages of this fiscal method are the relatively low implementation, monitoring and transaction costs, thus in theory achieving the emissions target at a much lower cost, and hence being more economically efficient. The ability to create large sums of public revenue is a strong benefit of fuel tax. Whilst taxation is regressive amongst motorists, the inequities resulting from tax increases could be largely offset by revenue redistribution and the scheme could be made more attractive to the public by hypothecating revenue into supportive measures, such as public transport improvements which would provide alternatives for those with the lowest willingness to pay for fuel. However, if the revenue was redistributed in the form of, for example, reduced income tax, it is foreseeable that the increase in personal income (as a result of reduced income tax) could be used to partially offset the increased fuel prices and hence cause underachievement of the emissions target. In addition to the environmental consequences of underachieving the emissions target, the impact on public perception and thus acceptability could be detrimental. Hence, revenue redistribution would have to be in a form that is not equal to charging people more for fuel whilst at the same time partly reimbursing the additional costs through increasing their income.

2.12 Conclusions

The main aims of this review were to explore the potential for the use of TPs in the regulation of emissions arising from personal transport. The review indicated a strong and growing political interest for personal trading in the UK.

The extension of the EU ETS to include mobile emissions could greatly increase the likelihood of the schemes described in Sections 2.6 and 2.7 being realised. In addition the UK Governments desire to include aviation in the EU ETS may set a precedent for the trading of externalities created by transportation modes. At least, it indicates a positive future for the possibility of using TP schemes in the transport sector. In addition, the knowledge that decision makers at the highest levels are considering TP schemes for such purposes validates further research in this area.

An evaluation of possible applications in the transport sector revealed a downstream tradable fuel permit scheme as the strongest design, having equity and acceptability advantages over an upstream design amongst fuel suppliers. A scheme amongst vehicle manufacturers was also evaluated but could not achieve the same level of reduction achieved by a personal scheme.

Effectiveness, benefits and fairness were identified as key factors in terms of public acceptability of a downstream TFP scheme. In order to further the investigation into the application of personal carbon trading as a key policy in the transport sector, it is imperative to explore such issues. However, as highlighted by the review, there is currently no empirical evidence regarding public response to a personal trading scheme. In addition, the scheme designs outlined in sections 2.6 and 2.7 were lacking details in terms of, for example, estimated financial costs, permit price and carbon reductions targets, which would be crucial elements in terms of designing a scheme in order to explore public response. Hence, to gain empirical data regarding response to a TP scheme, it would first be necessary to fully design a TP scheme.

A carbon tax on fuel was identified as having the greatest potential to achieve similar results as a TP scheme. It is likely that trading would be compared to taxation at a policy level prior to implementation. In addition, there is a growing interest within the literature regarding taxes versus trading (Roberts and Thumin, 2006; Keay-Bright and Fawcett, 2005). There are interesting questions regarding the trade-offs between a potentially unpopular policy with uncertainty regarding the level of effectiveness delivered, and a TP scheme with relatively high implementation and running costs, but a potentially high degree of effectiveness in delivery. Whilst TPs were perceived to receive greater levels of public support than pricing measures, there is no empirical evidence to support such suggestions.

Chapter 1 identified the need to significantly reduce carbon emissions from the transport sector. Given the potential to secure significant reductions and the growing strength of political interest, there is considerable scope to further investigate the application of TPs (Dobes, 1997; Crals *et al.*, 2003; Verhoef *et al.*, 1997; Raux, 2004). In consideration of the conclusions reached and the knowledge gaps highlighted, the following chapter sets out the research methodology.

Chapter 3

Survey design and implementation: the Tradable Carbon Permit scheme, fuel price increases and interview process

This chapter details each part of the survey work. Sections 3.1 and 3.2 describe respectively the working policy design of the Tradable Carbon Permit (TCP) scheme and a system of fuel price increases (FPI). Both policies were purposely designed in order to explore public response. Section 3.3 outlines the research questions addressed by the survey work, with the research hypotheses in section 3.4. The survey design is then presented in section 3.5, followed in more detail by the research process and stages of implementation in section 3.6, with sample statistics provided for the main survey.

3.1 The TCP scheme

This section describes the TCP scheme developed to satisfy the first study objective which, to recapitulate, was to design a personal carbon trading scheme to significantly reduce carbon emissions arising from the use of personal transportation. The TCP scheme was designed to serve as a realistic policy scenario for use in the public attitudes survey, hence it does intend to fully explore all related technical and implementation issues. The following sections provide an indication of how the TCP scheme could work across modes and how the scheme would work in terms of the individual, where issues related to the allocation of carbon permits, fuel purchase, temporal flexibility, trading options and facilities and public transport are discussed. In addition, estimates of financial costs relating to the TCP scheme are presented, together with estimated permit price and the subsequent effect on fuel price and fuel taxation revenue. Such issues were identified as being the most important in terms of the purpose of the scheme design (for use in a public survey). However, whilst they are not as fundamental to the survey, the requirements of the scheme, in terms of technology, trading facilities, and monitoring are also outlined.

3.1.1 Emissions goal to be achieved

The overall CO_2 emissions target is in line with the aim set out in the UK governments Energy White Paper to achieve a 60% reduction of CO_2 by 2050 (DTI, 2003), which is also proposed to become legally binding in the forthcoming Climate Change Bill (DEFRA, 2007) (see section 1.2 for further details). Thus, the emissions target for the TCP scheme is a 60% reduction of CO_2 from personal land-based transportation from 2004 levels to be achieved between 2005 and 2050. The start date of 2005 was selected for consistency purposes relating to the start date proposed in the individual interviews, and also to benefit from the use of current statistics relating to carbon and travel consumption and thus avoid complex forecasting which may have produced inaccuracies. For consistency with the transport statistics used, the TCP scheme is discussed and presented in terms of carbon rather than CO_2.

Chapter 2 highlighted the cap and trade design to be the most suitable for use amongst individuals, hence this design has been adopted. As the scheme is focused on personal trading, it would operate as a closed scheme including individuals only. In addition, a mandatory basis is assumed (see section 2.3.2 - 2.3.4 for more detail). In order to achieve the 60% reduction of carbon emissions by 2050, a limit would be placed upon the amount of carbon (converted into the fuel equivalent) available each year thus creating a carbon budget. In line with the emissions target, the carbon budget would decrease by 1.34% each year from 2004 levels, therefore reducing by 2.68% in 2006; and 4.02% in 2007, 5.36% in 2008 and so on until 2050. The gradual reduction in carbon availability allows society to steadily adjust. As the system progresses and the reductions become greater, individuals would be less dependant upon travel by carbon consuming modes as alternatives would be available, such as clean fuelled personal motor vehicles, and public transport. In addition, the necessity to travel is likely to decline as a result of the expected increase in demand for, and thus the provision of, local amenities, such as shops.

3.1.2 Geographic area

It is likely that a TCP scheme would be introduced initially in an area smaller than the EU in order to gain the experience necessary for application on a larger scale (i.e. monitoring and enforcement systems; resolving impracticalities). Hence, Great Britain is used as a case study. In addition, the statistics used in this study are calculated for GB, not the UK. Corresponding statistics produced for Northern Ireland are produced in a different format, thus making it difficult to combine the two sets of data. Whilst it was unnecessary for the purpose of this research to include a carbon budget for non GB residents traveling within GB, it is recognised that such issues would need to be addressed prior to policy implementation.

3.1.3 Commodity to be traded

The scheme would work on the basis that carbon permits are required in order to purchase carbon-containing fuel for land-based personal transportation modes (e.g. car, motorbike). Each carbon permit would correspond to 1 kilogram of carbon. Given the direct relationship between fuel carbon content and carbon emissions (Keppens and Vereek, 2003), the amount of permits required would be equal to the carbon contained within the fuel purchased. For example, if the fuel purchased contained one kilogram of carbon, permits to represent one kilogram of carbon would be required in order to purchase the fuel. Upon introduction of the system, it would be necessary to distribute information such as carbon content of fuels, and carbon emissions per mile in order to aid individuals to distribute the use of their carbon permits. Measures to reduce consumption should also be included, such as car sharing, trip-chaining, walking and cycling. Journeys made by public transport, cycling and walking require no carbon permits.

It is likely that the demand for public transport (PT) services would subsequently increase following the introduction of the TCP scheme, hence carbon emissions from public transport are likely to increase. In order to reduce carbon emissions from PT and thus to avoid partially offsetting the carbon reduced from personal transportation, regulation would be required. In conjunction with the personal TCP scheme, it is suggested that a business TCP scheme be established which would replicate the key principles of the personal scheme but would only include business travel. This would include, for example, all land based freight travel; self employed people business travel and travel undertaken on behalf of an employer. This would essentially create two trading schemes which operate on the same basis, however the allowance of permit trading between the personal and business market would require thorough examination with particular regard to the differences in purchasing power amongst the trading entities. PT could be included in the business TCP scheme, which would have the same emissions target as the personal TCP scheme and would require operators to produce carbon permits corresponding to the carbon content of their fuel purchases. This in turn would necessitate the uptake of clean fuel technology and increased efficiency of public transport vehicles and services. Such a scheme could increase the attractiveness of PT modes as personal carbon permits would not be required, therefore encouraging the usage of this 'permit free' mode. The amount of carbon currently emitted from public transport would be gradually reduced each year in line with a 60% reduction. However, placing such limits on carbon-containing fuel supply to PT modes may restrict the ability of operators to introduce sufficient levels of services to meet demand, which may in turn reduce the potential for replacing car journeys with PT modes. The requirement of PT operators to purchase carbon permits may therefore be introduced as the personal TCP scheme progresses, possibly in 2010 rather than 2005, to allow for other measures that reduce the need to travel, such as local shops and telecommuting, to become established. Taxis could also be included in the business scheme, however it is suggested that the carbon used whilst transporting a customer should be payable by the customer and subsequently credited to the carbon permit business account of the taxi owner/company. Hence, the remainder (for example, resulting from journeys between customer pick up) should be accountable to the taxi driver/owner in order to encourage the uptake of increased fuel efficient driving and vehicles in addition to the purchase of clean fuel vehicles in the long term.

3.1.4 Initial carbon permit allocation

In several places the literature review presented in chapter 2 identified suggestions that the provision of a free permit allocation would minimise the equity impacts resulting from increased fuel price and could therefore be more publicly acceptable (Starkey and Anderson, 2005; Raux and Marlot, 2005). Hence, at the beginning of each calendar year, half of the TCP schemes' annual carbon budget would be equally distributed free of charge to each person aged 17 and above. This method would provide individuals with a set allocation of carbon permits, during the use of which they would not incur any additional costs during fuel purchase. This method also allows individuals to adapt gradually and, as the system progresses and carbon availability declines, individuals would be less dependant upon travel by carbon consuming modes as alternative measures would have been implemented, such as public transport, clean fuelled vehicles and local amenities. Therefore, demand for carbon would gradually decline over time as carbon availability also gradually declined. Chapter 2 described several alternative means of allocating free permits, however this method was based on the age that an individual in the UK is legally permitted to obtain a driving license. It is recognised that prior to policy implementation, it would be necessary to fully explore the various methods of permit allocation.

When the free permit allocation has been used, all additional permits must be purchased from the central permit market. Alternatively, any of the free allocation that is unused can be sold back to the government, who would then sell to those people wishing to purchase additional permits. The government would also sell the remaining half of the annual carbon budget through the central permit market in order to raise revenues. The inclusion of hypothecation would have several purposes:

- o It increases the financial viability of the scheme as revenue raised would be used to fully fund the scheme (monitoring, implementation, enforcement and operating costs), thus removing the burden from tax payers (public money would otherwise be required to fund the scheme).
- o Funds available to invest in public transport improvements would increase political acceptance of the system as 'carrots' such as transport services for those unable to reduce their demand for travel or pay for additional permits would be provided, thus reducing social exclusion.
- o It introduces visibility into the spending of revenue raised as the investment would be visible (e.g. improved public transport and local services). Political acceptance is increased if the benefits of the system are tangible (Small and Gomez-Ibanez, 2000; Whittles, 2003). In addition, the visibility of hypothecated funds and its usage would increase public acceptance as there would be no confusion regarding the purpose of fund raising (Jones, 1995).
- o Investment in public transport would provide individuals with more options for reducing their carbon consumption, which is particularly important in the early stages when personal clean fuel modes are in limited supply.
- o If all permits were distributed free of charge the government would not gain any revenue to fund the scheme and invest in supportive measures such as public transport.

3.1.5 Temporal flexibility

The permits sold by the government could be distributed at the beginning of each calendar year along with the free permit allocations. However, in order to reduce the risk of a permit shortage, it is proposed that the permits for sale through the central market would be released gradually throughout the year, which could be for example an equal amount every month or take into account any seasonal changes in demand. Whilst it is unlikely that any carbon permits would not be used, any unused carbon permits may be carried forward to the next year as this would not affect the overall emissions target. However, there are several potential problems to consider regarding permit release. There is a risk that demand for permits may outweigh supply to the extent that all permits are sold before the year ends. Releasing permits gradually throughout the year may partly resolve this, or use of demand to determine permit price, but nevertheless it is still a possibility. Such an event has the possibility of inducing scenes similar to those occurring in response to the fuel strikes in September 2000, where many people were unable to purchase fuel and thus use their cars (Lyons *et al.*, 2002). This could be a serious problem for those individuals who are car dependant and requires further thought.

Hoarding of permits is also a concern as this would affect availability and thus consumption. It is therefore important to discourage hoarding by removing the benefits of doing so, which could be achieved by using a set price for permits. Some individuals may wish to stockpile permits for use in possible emergency situations, which could also affect permit availability. Placing a limit on the amount of permits any one carbon account can hold at any time would perhaps resolve this.

3.1.6 Trading facilities

Secure facilities for buying and selling permits would be required. All trading would have to be conducted in real time in order for carbon availability to be established before any transactions are carried out, therefore a real time electronic data base must be established. Trading could occur via the internet where individuals could also access their own permit accounts in order to check the balance and transactions (using the same principles as internet banking).

As they are perceivably accessible to the majority of individuals and would have the facilities to carry out cash transactions, it may be possible to trade at Post Office outlets or using Paypoint machines in newsagents with the use of a carbon permit card. Electronic Trading Machines (similar to Automated Teller Machines) could be situated at shopping outlets, or be accessed on-street (as some cash machines currently are). Alternatively, it could be possible to link existing ATMs to the carbon database which would reduce the necessity for new equipment (Raux and Marlot, 2005). It would also be possible to buy and sell permits whilst purchasing fuel through existing Chip and Pin machines which would be adjusted to read the chips in the carbon cards. Research by Starkey and Anderson (2005) suggests that it would be possible to create such trading facilities using current information technology.

3.1.7 Technology

Each person would be issued with an electronic swipe card which must be used when purchasing fuel and selling or buying permits. Each person would be able to access their account details in real time (check balance, look at transactions made) as all information would be stored on a national electronic database. Research conducted by Starkey and Anderson (2005) suggests that such a database would be possible using current information technology. The accounts would be similar to those currently used for individual banking. Carbon accounts could be stored on identity (ID) cards, which are currently being considered by central Government (Home Office, 2004), and would reduce the implementation costs of the TCP scheme. However, should the ID scheme not become apparent, or be delayed, then an alternative approach could be used. The onus of data collection and production of carbon cards could be removed from the government and placed onto the individual by allowing people to join the TCP scheme, which would be necessary for anyone wishing to purchase fuel. Individuals would be required to complete an application form (or perhaps go to a designated registration address in their area) which would provide all of the necessary details. The potential problems related to this method are false registration and false use of identification and therefore requires further thought. In addition, the distribution of the free permit allocation would vary in that only the people registered would receive a free allocation. Whilst this could be favourable amongst carbon users as there would be a larger free allocation and/or more carbon available to purchase, it loses the benefit of providing a form of compensation and a 'stake' in the environment to those individuals who do not consume carbon.

A registration fee would be requested, the amount corresponding to the production and administration costs of the carbon card. Similar methods are currently used for the administration of passports, television licences and driving licences. Such a method would reduce the dependency of the TCP scheme upon the introduction of the ID card scheme and also reduce the cost burden of data collection, production and administration of carbon cards should the TCP scheme not be introduced in conjunction with the ID card scheme. In addition, it is possible that the TCP scheme would be more acceptable if it was introduced independently of the ID card scheme.

Trading outlets (see trading facilities) would have to access the real time electronic database, which could perhaps be connected to landlines as they are already installed in most locations and the network could be expanded, therefore reducing the necessity of a separate communications system.

3.1.8 Monitoring and enforcement

There are potential problems to consider in relation to the carbon permit market. By reducing the availability of permits and increasing their value over time, the demand for, and thus supply of, illegal permit markets is likely to increase. Hence, the legal permit market would be competing with illegal markets. Such activities would jeopardise the emissions target and would also remove value from the carbon permits, revenue from which is likely to be vital to the running of the system (this problem could also occur if fuel prices were increased as a sole measure to reduce carbon emissions). Hence, adequate monitoring of the scheme is essential. In order to reduce costs, it is suggested that monitoring of carbon permit consumption would be carried out upstream, amongst fuel wholesalers and producers, rather than downstream (upon individual fuel consumers). The wholesalers would be required to produce an amount of permits equal to the carbon content of their annual fuel sales. In order to detect fraudulent activities the scheme would be monitored regularly at the individual level, which would be continuous throughout the year. This would involve the monitoring of trading transactions in order to track permits, monitor usage and detect unusual activity, aided by the use of electronic swipe cards (ability to track switch, debit, and credit transactions). The requirement of using chip and pin technology in order to purchase fuel and permits would enforce the scheme. In addition, in order to aid the identification of illegal permits each legal permit could be given a unique identification number. This was demonstrated in the RECLAIM programme which featured an Allowance Tracking System in order to control unorthodox permit transfers and use (see section 2.4). All personal information collected through the TCP scheme database would be classed as confidential and hence should not enter the public domain.

3.1.9 Estimated financial costs

The financial costs of the TCP scheme could seriously affect its attractiveness and feasibility as a policy option, and therefore whether or not it would be implemented. In order to reduce reliance on public funds, it would be preferable if sufficient amounts of revenue to cover all costs related to the TCP scheme were raised from the sale of permits.

There are several components of the TCP scheme that compose the overall costs:

- Establishment of a permit market;
- Installation of trading facilities;
- Information campaign;
- Investment in PT; cycle and walking facilities; and local amenities;
- Operating costs (this may include the use of electricity to power databases);
- Monitoring/maintenance costs.

Investment in public transport, cycle and walking facilities and local amenities and operating costs would be annual. The implementation costs could be recuperated as the system progresses, therefore dividing the costs over the period of the system. Alternatively, the implementation costs may be funded by central government revenue as the scheme has an important purpose and would greatly benefit all citizens. This may be possible, considering the recent estimated investment of £30 billion for an electronic patient record scheme for the NHS.

In order to provide an indication of the amount of revenue required for the TCP scheme each year, the costs outlined above must be estimated. Table 3.1 displays costs that are based on the revenue raised from permit sales being sufficient to fund all costs (implementation and operating costs), and also replace fuel tax losses. In order to demonstrate the total amount of revenue required both with and without implementation costs, the estimates described above have been calculated for the years 2005 and 2006. The total amount of revenue required from permit sales would increase each year in order to offset losses of fuel taxation revenue. For example, the total amount required in 2005 is estimated to be £594.1 million, increasing to £776.5 million in 2006. It is assumed that the system would be introduced in conjunction with the ID card system, thus removing costs related to a population register, the production and distribution of swipe cards, and the updating of the population register.

Table 3.1: Example of financial costs relating to the TCP scheme (£m)

	2005	2006
Information campaign	8.3	-
Operating costs	175.1	175.1
Scanning equipment	40.5	-
Public transport investment	139.0	139.0
Lost fuel tax revenue	231.2	462.4
Total costs	594.1	776.5

Given that the TCP scheme is a new concept, a national information campaign would be essential. It is proposed to include leaflets to each household; posters on PT; posters on billboards; advertisements in newspapers and on television and the radio; and features on national and local news programs. The estimates for the information campaign were based on the UK governments' campaign 'preparing for emergencies'. The costs for this campaign were estimated to be approximately £8.3 million and included advertisements on the radio (local and national), television, and the delivery of a 22 page booklet to over 25 million UK households (HM Government, 2004), and are thus considered to be similar in scope to the requirements of the TCP scheme.

In order to derive an estimate of operating costs, a range of organisations were considered. Whilst it is difficult to determine the exact functions of the TCP scheme, the UK passports agency was thought to have similar functions as it is involved in issuing documents, monitoring accounts and maintaining a database. The annual cost of sales in 2003 equated to £115.9 million which includes staff costs, telecommunications charges including a call centre, and data capturing. The UK Customs and Excise were also considered due to the monitoring and maintenance of a database. With annual operating costs of £1,097 million in 2003, it was decided that the functional scope was much greater than that required for the TCP scheme, for example it is possible that the TCP scheme could be operated from one location as the majority of functions would be electronic, in comparison to the Customs and Excise which has an office at each port and functions involve manual checks which are more resource intensive. The DVLA was considered to be the most indicative in recognition of the annual administration requirements (posting reminder letters for annual road taxation payments) which may be similar to those involved in the distribution of information relating to the annual carbon budget at the beginning of each year; the use of one location; and the maintenance and monitoring of individual accounts. The annual operating costs equate to £193.7 million, which includes staff costs, IT expenditure, telecommunications, stationary, and postal expenses. There are some costs that are not relevant to the TCP scheme, such as the payment to medical practitioners, and Northern Ireland agency costs. These costs have therefore been removed to provide an estimated annual operating cost of £175.1 million. This cost may be reduced further as it is perceivable that more functions could be carried out electronically, for example updating the annual carbon budget and individual accounts in comparison to the annual requirement for a road tax disc to be displayed inside vehicles, and the periodic renewal of driving licenses.

In order to buy and sell carbon permits using the electronic swipe cards, electronic scanning equipment would be required at trading outlets. The costs for the scanning equipment (hardware and software) are based upon the unit costs of Chip and Pin machines, which equate to £1,500 per point of sale. There are approximately 11,000 petrol stations and 16,000 Post Office outlets in Great Britain, which equates to costs of £16.5 million and £24 million respectively if each location had one machine. The total cost of scanning equipment has therefore been estimated at £40.5 million, however this cost could increase if more than one machine was required at each trading outlet. Conversely, this cost could be reduced if it was possible to integrate the trading procedure into the scanning equipment currently used for the Chip and

Pin system. This requires further investigation before the cost estimate can be improved.

Car journeys would be displaced as a result of the annual reductions in carbon availability, it is therefore important to provide sufficient levels of public transport for use as alternative modes. This is particularly important at the beginning of the system before there is an adequate provision of local amenities that reduce the need to travel and may thus be reduced as the system progresses. Whilst it is unknown exactly how many car journeys will be displaced onto public transport, for example some journeys may be abandoned or made using another mode, an initial estimate can be derived based upon the annual reduction of carbon availability. In 2003, car use accounted for 678 billion passenger kilometres, and public transport (bus and train collectively) accounted for 96 billion passenger kilometres. Due to a decline in fuel availability of 1.34%, it may be assumed that car passenger kilometres also decline by a similar amount. The displaced car passenger kilometres may then be added to public transport passenger kilometres, which results in an increase of 9.5%[4]. This percentage increase can then be used to estimate the amount of investment required. For example, local government expenditure on public transport (including revenue support for subsidised routes) amounted to £1462 million in 2002/03 (DfT, 2005). Based upon the estimated increase in public transport kilometres (9.5%), a maximum of £139 million would be provided from permit revenue. However, this estimate does not consider the financial profit increases for operators as a result of business expansion which in turn is likely to attract private investment, therefore reducing the reliance upon carbon permit revenue. It is expected that PT operators would maximise the business expansion opportunities offered by the TCP scheme and invest in new vehicles and service expansion, which may reduce the requirement of permit revenue. In addition, the need to travel would gradually decrease as local

[4] 1.34% of 678 billion passenger kilometres = 9.0852 billion passenger Km. 9.0852 as a % of 96 billion passenger Km = 9.46%.

facilities and services are provided, which would reduce the requirement for PT and thus investment.

Fuel taxation revenue would be impacted negatively as a result of the reduction in carbon availability and thus fuel sales. This revenue is an important source of government funds and is likely to be accounted for, therefore the replacement of lost fuel taxation revenue could also be required from carbon permit revenue. The amount of permit revenue required each year was estimated using the fuel taxation revenue in 2003 (£17,259 million) and the annual reductions in carbon availability. For example, in 2005 fuel sales would be reduced by 1.34%, resulting in a loss of £231.2 million. This loss would increase each year in line with the annual carbon reductions, as also demonstrated in table 3.1 and figure 3.1 (full details are contained in appendix 1).

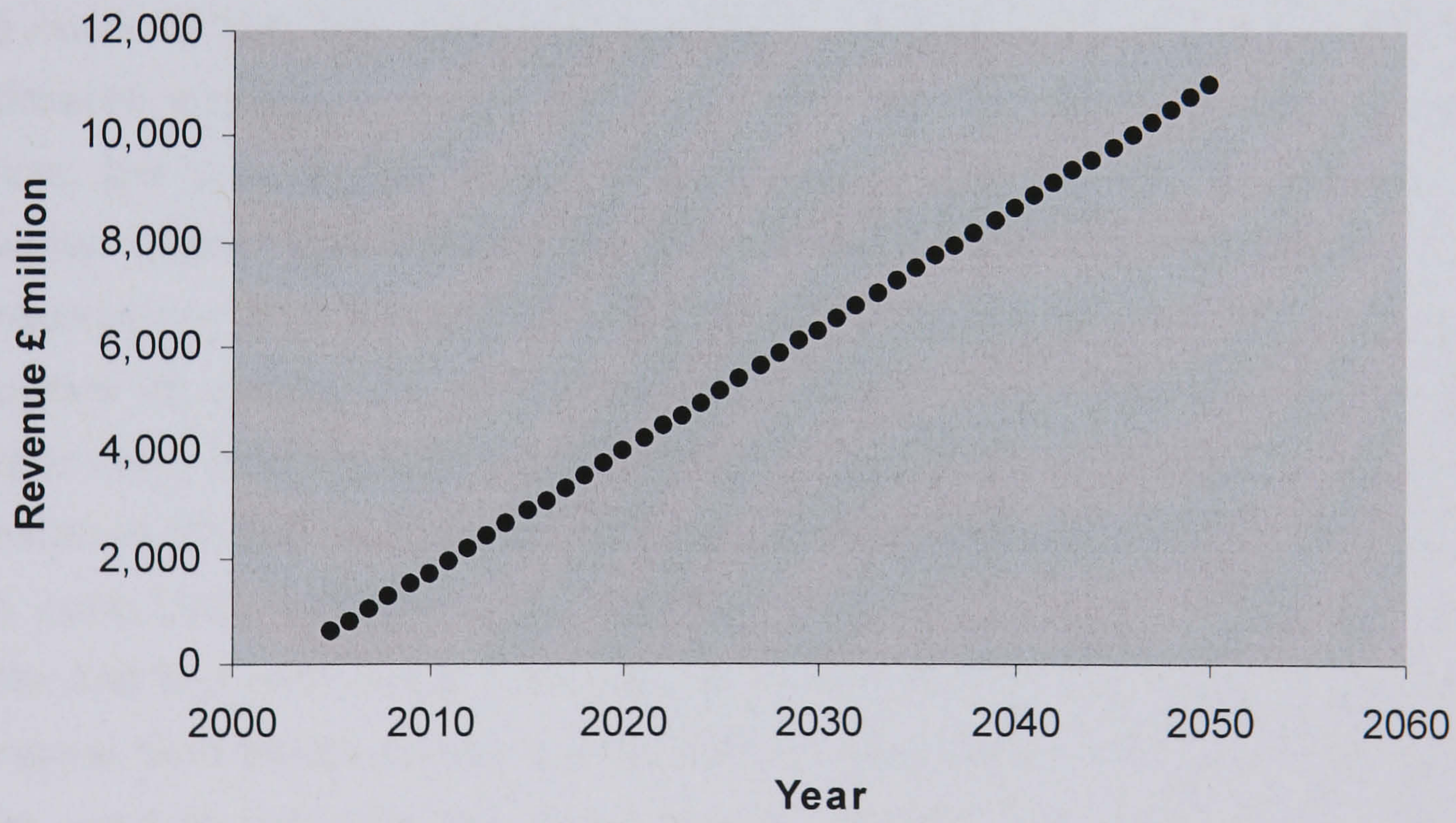

Figure 3.1: Revenue required from permit sales to fund all costs and offset losses from fuel taxation revenue.

The amount of revenue required increases each year as a result of the annual decrease of carbon availability (1.34% per year from 2004 levels - see Appendix 1 for further details), which results in reduced fuel and permit sales. There are no estimated costs provided for investment in local amenities, and cycling and walking facilities, thus there remains scope for improvement. However, there would be additional revenue to that estimated here should the permits be sold on an open market with a minimum fixed price. In addition, the annual costs are assumed to remain the same each year but could be reduced due to technological improvements, therefore reducing the estimates calculated here.

3.1.10 Derivation of permit price and free permit allocation

Given that the fundamental requirement of the permit sales would be to cover the costs of the TCP scheme, the permit prices derived were based on the estimated monetary costs (shown in figure 3.1). To derive annual permit prices, the total annual cost of the TCP scheme (including replaced fuel tax revenue which increased each year in line with the 1.34% reduction in carbon consumption) was divided by the annual carbon budget, giving a price per kilogram of carbon. To derive the initial carbon budget, the total amount of carbon from road transport and rail were used. In 2004, rail and road transport consumed 39,000 million kilograms of carbon (DfT, 2005). Car and motorcycle use collectively accounted for 59% of this amount, with rail accounting for 5.1% and bus consuming 3.8%, giving a total of 68%. As the study focuses on personal land based transport, the carbon emissions from these modes have been used to calculate the initial carbon budget of 26,165 million kilograms carbon[5] (see appendix 1 for full details). Thus, for example, in 2005 the total costs were £594.1 million and the annual carbon budget was 26,165 million kilograms, hence £594.1 million/26,165 million gives a permit price of £0.02

5 68% of 39,000 million Kg Carbon = 26, 520 million Kg Carbon. This amount would be reduced by 1.34% to provide the initial Carbon budget: 26, 520 - 1.34% = 26, 165 million Kg Carbon.

per kilogram carbon. It was assumed that half of the annual carbon budget would be allocated free of charge to individuals (see section 3.1.2), thus the annual costs of the TCP scheme would have to be obtained from the sale of half of the carbon budget, hence the price per kilogram of carbon was multiplied by 2. Figure 3.2 displays the price of permits throughout the duration of the TCP scheme.

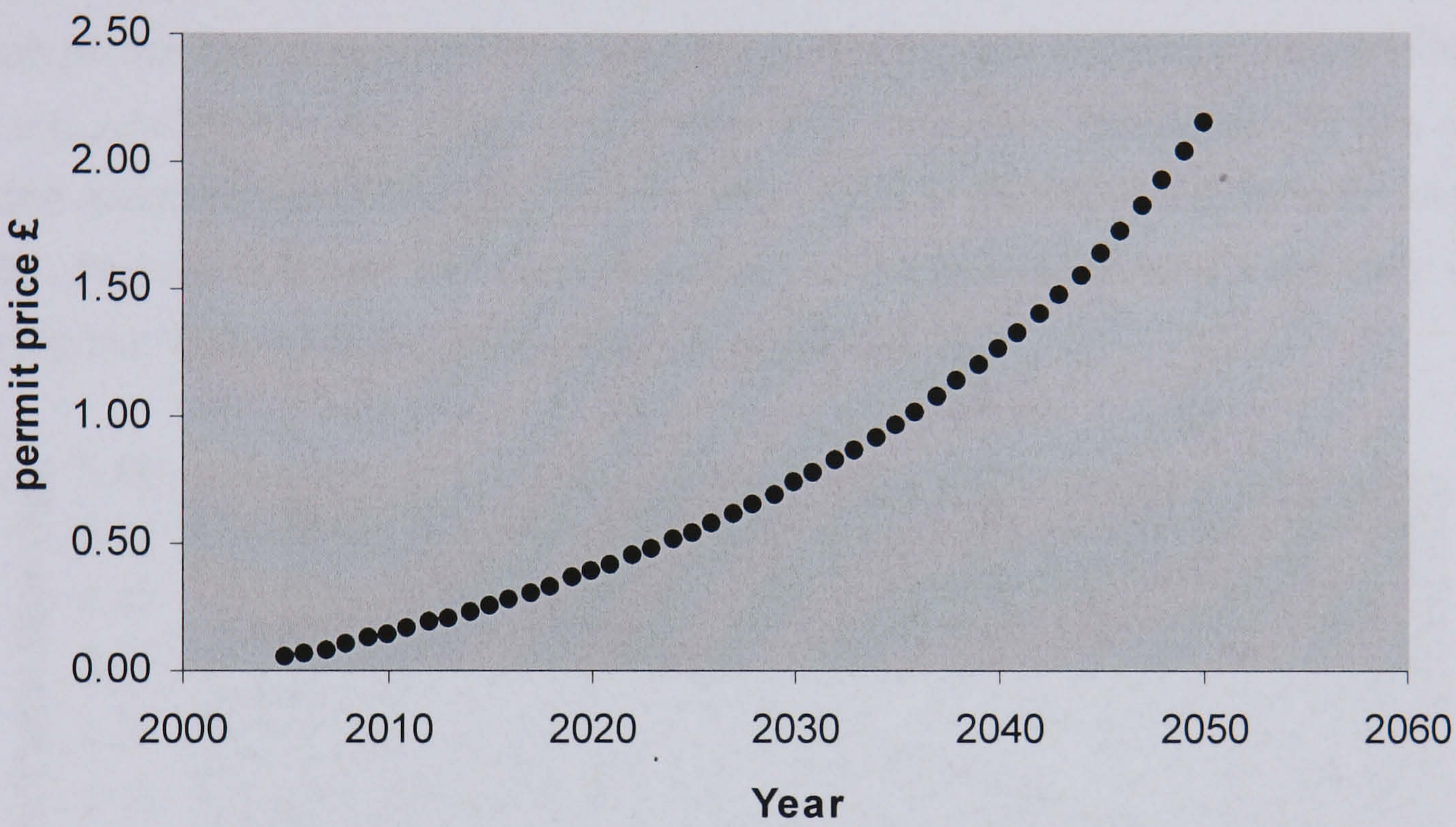

Figure 3.2: Permit price (per kilogram of carbon) during the TCP scheme

For the purpose of this research, fixed permit prices were used given the complexity and potential inaccuracy of predicting prices on an open market. In addition, as the TCP scheme does not rely upon willingness to pay to achieve its targets, the use of a market to determine price is not essential. However, before selection of a pricing method, both should be assessed for their relative merits, particularly in terms of costs (for example to establish market mechanisms), feasibility (which method is the easiest to implement on a practical level) and implications on demand (importance of price signal to regulate consumption).

To derive the annual free allocation of carbon permits, the annual carbon budget related to the personal transport use (i.e. subtracting the proportion relating to bus and rail) was divided by 2 (to represent the half that would be given free of charge), then divided by the number of adults in the UK aged 17 and over (46, 161, 981). This provided a free carbon allocation per person for each year of the scheme. For example, 11,351 million kilograms/46, 161, 981 adults equates to 245 kilograms per adult in 2005. To obtain the monetary value of the free weekly carbon allocation, the annual allocation was divided by 52 e.g., 245/52 = 4.7 kilograms/week. This was then multiplied by the value of the permits per kilogram, for example 4.7 x £0.04 = £0.18 per week in 2005. Figures 3.3 and 3.4 show the free permit allocation and monetary value during the TCP scheme (also shown in appendix 1).

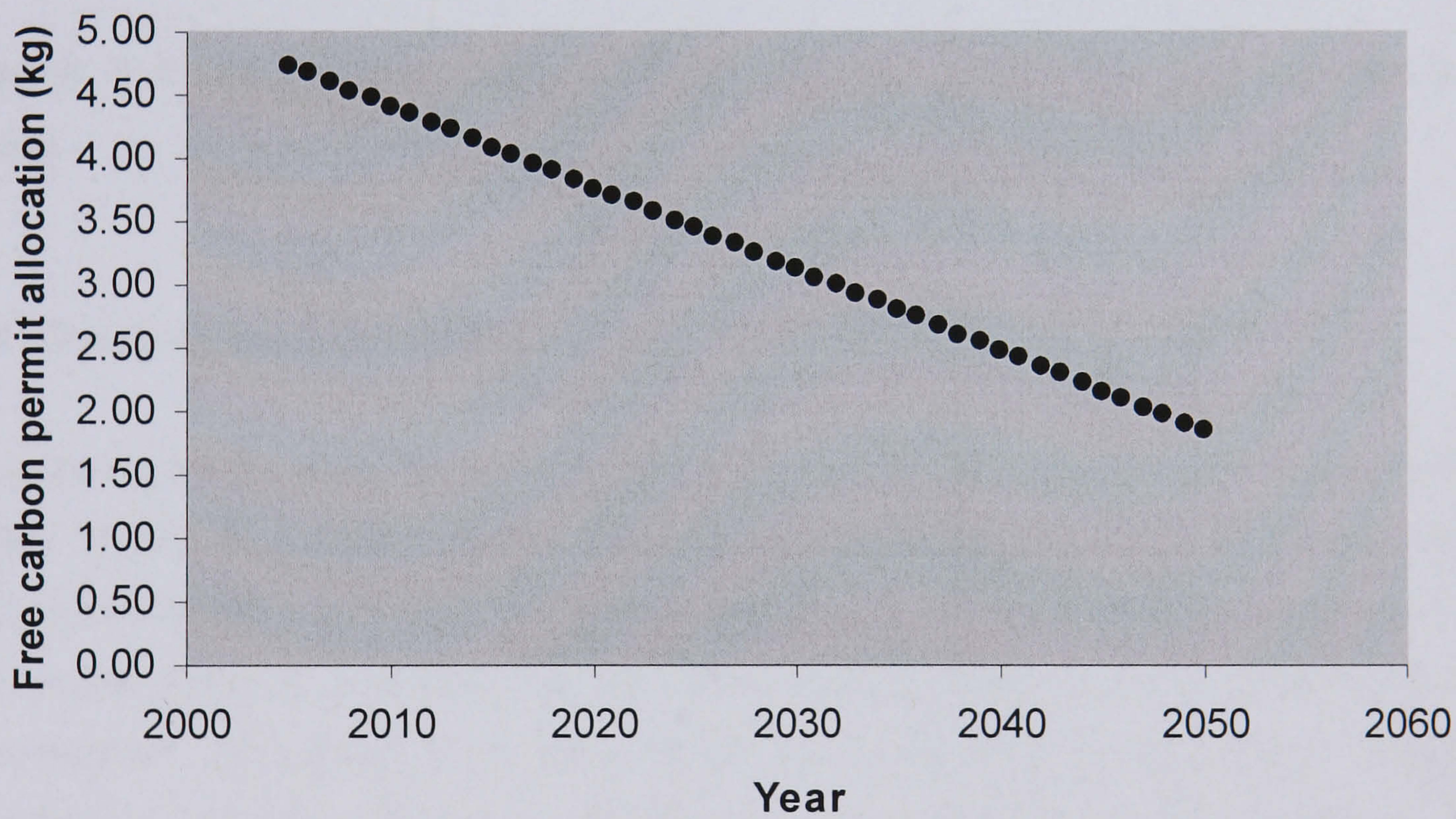

Figure 3.3: Free carbon permit allocation per person per week during the TCP scheme

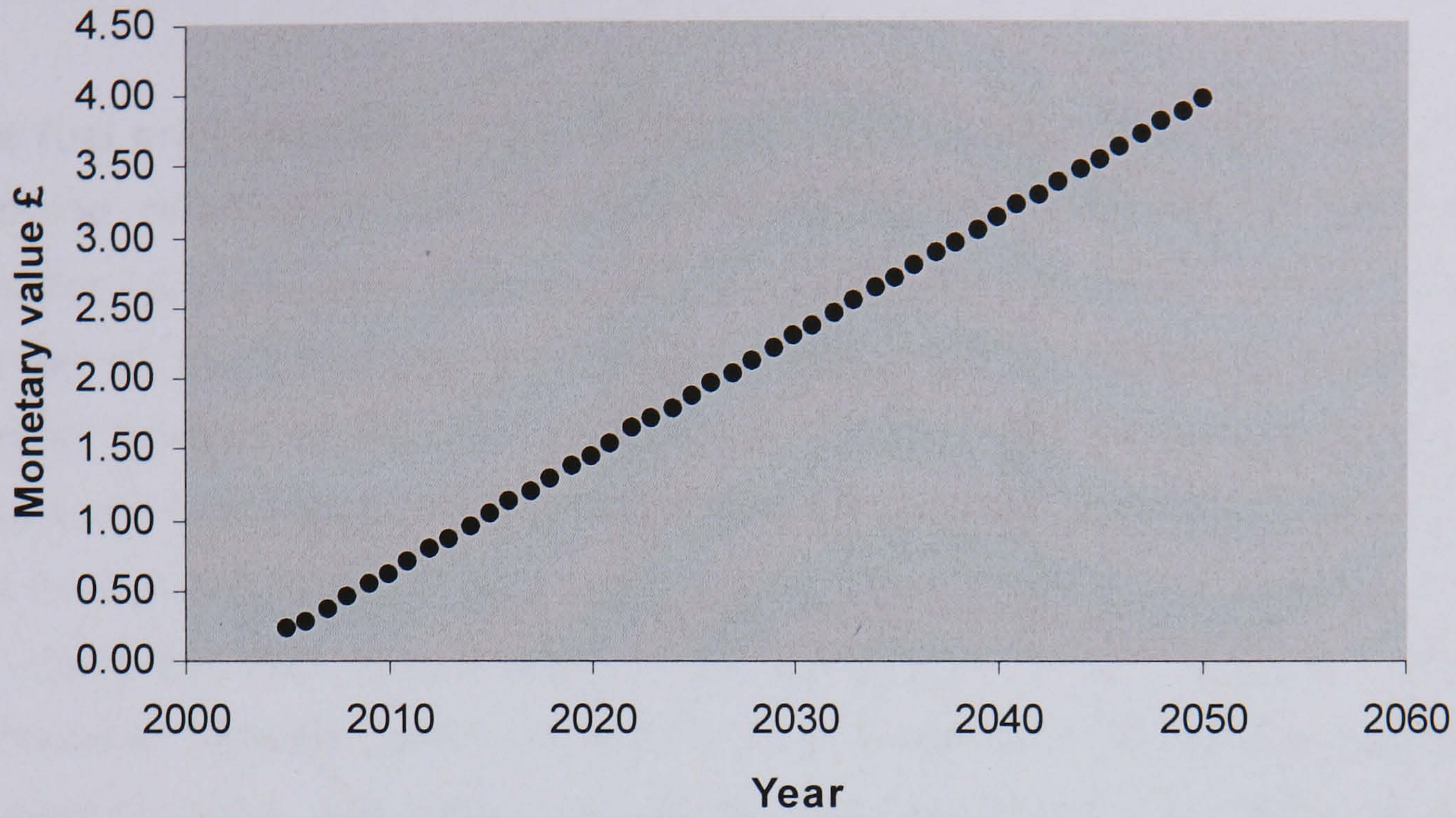

Figure 3.4: Monetary value of free carbon allocation per person per week

3.2 The fuel price increase

A system of fuel price increases (FPI) were designed to provide an alternative policy to the TCP scheme. The FPI would be applied throughout Great Britain and would affect everyone who purchased fuel for personal motor vehicles. The FPI would provide revenue for an annual investment in public transport, an information campaign and also cover annual monitoring costs (regular monitoring of fuel sales would be required, which could result in the adjustment of fuel prices if they were not having the desired effect on consumption and/or in response to oil price fluctuations). Surplus revenue would be invested into the provision of supportive measures, such as localisation of amenities and improved paths and cycle lanes.

3.2.1 Derivation of fuel price increases

The fuel price increases were calculated using conventional price elasticities of demand relating to fuel consumption, which were derived by Graham and Glaister (Glaister and Graham, 2000; Graham and Glaister, 2002) following a survey of the literature on motorists' response to fuel price increases. The survey covered numerous international studies which had derived short and long term fuel demand elasticities based on empirical evidence (including long-run household surveys) over time. Graham and Glaister concluded that, based on evidence that has proved to be consistent across studies, there are differences between the short and long run elasticities of fuel consumption with respect to price, with short term elasticities typically in the region of -0.2 to -0.3 and long term elasticities between –0.6 and –0.8. There was clear and consistent evidence that, in many countries, in the long run there is a significant, although less then proportionate, response. In all cases, the survey revealed that it takes time for people to adjust, hence the initial impact effects are smaller than effects in the long term.

Hence, for the current study, in order to achieve a 60% reduction of carbon emissions from personal road transport by 2050[6], a short run elasticity of -0.25 was used for the first five years, increasing by -0.05 each year until the long run elasticity of -0.7 was reached, which was applied thereafter up to 2050 (see Appendix 2). In addition to the estimated reduction in vehicle kilometers, the elasticities used include the impact of efficiency on fuel demand as people would be expected to use more efficient fuels and vehicles as a result of the price increases (Glaister and Graham, 2000; Graham and Glaister, 2002). The increased elasticity value of -0.05 each year until -0.7 was reached on the assumptions that individuals would be able to make greater changes to

6 Based on the assumption that the relationship between fuel consumption and carbon emissions is relatively direct i.e., a 60% reduction of fuel consumption would result in a 60% reduction of carbon emissions. It is recognised that this assumes current fuel types (petrol and diesel) remain the same, which is unrealistic over such a long time period particularly given the finite supply of oil and increasing global demand.

their fuel consumption in the long run when supportive measures were more widely available, such as increased provision of public transport services, improved facilities for clean modes (cycle lanes, footpaths), car pools, teleworking, and local amenities such as shops that reduce the need to travel. As such measures require time to be established, it is likely that the ability to reduce fuel consumption in the short run would be limited, hence the smaller price increases compared to the long run assumptions. This is demonstrated in figure 3.5 which displays the estimated price of fuel per litre over the duration of the FPI.

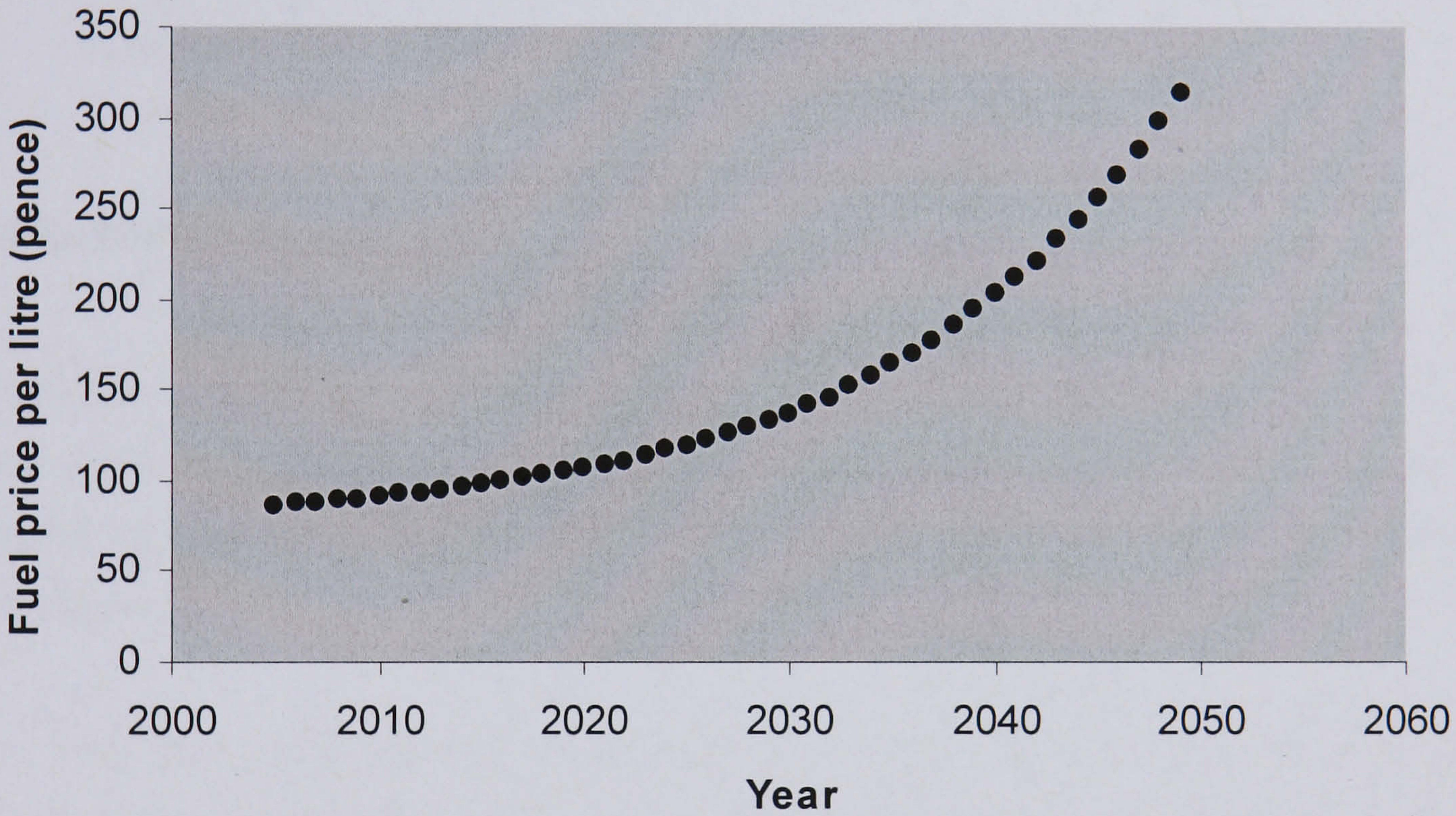

Figure 3.5: Fuel price per litre for the FPI policy

3.3 Research questions

Chapter 2 highlighted a lack of research reporting the public response to a personal carbon trading scheme. In addition, fuel price increases were recognised as having the potential to achieve the same carbon reduction target in a more economically efficient way. Thus, to gain empirical evidence related to both policies, the main purpose of the survey work was to investigate the following questions:

- What are the behavioural responses to a TCP scheme/FPI and the subsequent implications of such responses upon lifestyles and travel behaviour?
- Is a TCP scheme/FPI perceived to be effective, fair and publicly acceptable as a measure to reduce carbon emissions from the transport sector?
- What are the key factors influencing acceptability of the TCP scheme/FPI?

3.4 Research hypotheses

In relation to the research questions outlined in section 3.3, several outcomes were expected based on the evidence contained in the literature review (see chapter 2) and perceived logical relationships between personal characteristics and response:

- The TCP scheme will be accepted by the majority of respondents as transport will be perceived as a major problem where 'something has to be done' (Jones, 1995, 2003).
- Providing the concept of the TCP scheme is understood, it will be perceived as the most effective and fair measure.
- Those individuals with high fuel consumption (car users) will have the strongest opposition to the TCP scheme.
- Those opposing the TCP scheme and FPI will do so mainly on the grounds of fairness (policies perceived as another form of taxation, infringement on freedom), and necessity (problems do not warrant such a system), the latter objection being particularly prevalent amongst those with low problem perception.

- o Acceptability of the TCP scheme will be greatest where personal benefits are high i.e. low fuel consumers who can sell excess permits (prevalent amongst low income groups), those with high problem perception and concern for the environment.
- o Fuel tax will be a preferred measure amongst those with high incomes, high value of time and high travel consumption, whereas permits will be preferable amongst those with low incomes, those with low travel consumption, and those who have equity concerns.
- o Behavioral response will mainly be switching from car to bus for certain journeys, walking for short journeys, shortening leisure journeys, and reducing the amount of non-essential trips. The most common response will be trip combining.
- o Pull measures, such as public transport improvements, will be preferable to both the TCP scheme and the fuel price increases.
- o High fuel prices would be preferable to lower prices where fuel availability is uncertain, particularly amongst high carbon consumers and high incomes.

3.5 Methodological options

A crucial aspect of the research was to determine the methodological approach in terms of a public survey, a survey amongst academics/government/businesses or a more theoretical/econometric approach. In relation to the latter, investigating the demand for carbon and subsequent price; investigating the impact of varying permit allocations on demand; the use of formal Stated Preference techniques to assess preference between the TCP scheme and FPI and also assess willingness to pay for increased certainty of fuel (in relation to the FPI or an increased allocation of free permits in the TCP scheme), are all examples of potential methods. However, whilst all of these approaches could provide useful, original and interesting information that could contribute greatly to the design of a TCP scheme, it was decided to focus the survey on public response as it is possible that this could highlight some key aspects for further investigation given that personal carbon trading is essentially still a theory yet to be fully designed and implemented in practice. For example, given the lack of empirical evidence regarding public response, it is completely unknown whether the concept of personal carbon trading would be acceptable to the public and whether it would be an effective method of stimulating behavioural change. Hence, in order to investigate the issues underlying the political feasibility of personal carbon trading and thus whether the policy could progress beyond a concept, it was decided that a largely qualitative public response was most crucial at this stage of policy formulation.

3.6 Survey design

Several methods were considered, including a postal based survey, an internet based survey, interviews with individuals conducted using a telephone, focus groups and face to face interviews with individuals. Given the perceived importance of qualitative data in this study, the use of an internet based survey or a postal survey where considered unsuitable as open questions may have been a burden and therefore resulted in low response rates. In addition, as the TCP scheme was likely to be a new concept for most respondents, it was considered essential to provide an opportunity for respondents to ask questions and thus to ensure the policy had been understood before the questions began. Focus groups were considered, however, the attention and time required from each respondent made a group approach unsuitable particularly in terms of recording behavioural response. In addition, equal treatment was considered important in terms of asking each respondent the same questions which would not have been possible in a group environment. The influence of group discussion was also considered in that it is highly possible that the opinions of others within the focus group could influence individuals' responses – in this study it was considered important to capture 'uninfluenced' opinions. Hence, the approach was narrowed to a focus on individuals. Telephone interviews could have been used, however, the use of the software to record behavioural response required individuals to be able to see the software in use i.e. the computer screen. Whilst there are recognised benefits of using methods such as postal surveys, internet surveys, telephone interviews and focus groups, for the purpose of this research face to face interviews with individuals were considered the most appropriate method of answering the questions presented in section 3.3. A combined approach could have been adopted, for example, conducting a series of focus groups and individual interviews. However, in consideration of the resources available it was essential to fully pilot one method and ensure equal treatment of respondents in order to provide a comparative sample of responses.

Prior to the interview, participants were asked to complete and return a 7-day travel dairy, recording for each trip the mode used, origin and destination, travel time, journey distance and number of people on the trip (see appendix 3). The purpose of the diary was to provide for each respondent a calculation of current carbon consumption from personal transport, to be displayed and discussed with the use of purposely designed software during the interview (explained in detail in sections 3.6.2 and 3.7.1). In addition, the diary served to provide a baseline against which changes made in response to the policies could be measured. A week is considered to be a reasonable period to identify most regular trips and is also a good period over which to consider changes (Bristow *et al.*, 2004). Respondents were asked to record only personal trips i.e., not trips that were made on behalf of their employer, and to complete the diary during a period that they considered to be normal or routine, i.e., avoiding holiday periods. The diary also contained space to record the details (make and model, age and fuel type) of three vehicles (it was made clear that this did not include public transport modes or taxis). A similar approach is used for the National Travel Survey conducted annually by the UK department for transport.

The interviews were formally structured using a combination of open and closed questions. The latter were selected in order to gain quantitative data, whilst the open questions were designed mainly to follow on from the closed questions in order to provide detailed and undirected responses thus adding depth and providing respondents with the opportunity to express their exact opinion without being constrained to pre-set answers (Coolican, 1999; Robson, 2002). In all cases, further detail/elaboration was requested where appropriate, for example when open questions were answered 'yes' or 'no'. In order to quantify responses to the attitude measures, likert 7-point bipolar scales were used (Coolican, 1999). Each interview was tape-recorded to aid data analysis, after obtaining consent from the participant. Participants were assured that full confidentiality would be maintained throughout the research period and were encouraged to ask questions regarding any aspect of the interview or the policy measures discussed, if they were not fully understood. In order to avoid the encouragement of response bias, all questions and explanations were delivered by the interviewer in an impartial manner. At the end of the interview, participants were asked for any descriptive details that were considered too sensitive to ask during the selection process, including income and age (see appendix 9). The interviewees were offered a monetary reward (£10 per person) upon completion of the interview and thanked for their attendance.

The interview was arranged into three main sections, each having a different topic and purpose (see appendix 4 for interview questionnaire). The following sections outline the purpose of each part of the interview.

3.6.1 Section 1: Concern for the environment, problem perception and knowledge

Section one was designed to provide for each respondent a measure of concern for the environment; problem perception (related to current levels of road traffic); and awareness/knowledge of transports contribution to environmental degradation and health problems. Section one was considered to be a crucial part of the interview as it is logical to assume that the perceived fairness and acceptability of a measure to reduce CO_2 from the transport sector would be influenced by the degree of concern for the problem and the level of knowledge regarding the negative impacts of the problem (Fujji *et al.*, 2004). This assumption is supported by results from a study conducted by Rienstra *et al* (1999), where the results from an ordered Probit analysis revealed problem perception to strongly influence public support for road pricing.

3.6.2 Section 2: Behavioural response, impacts and acceptability of the Tradable Carbon Permit scheme

The second section of the interview began with an explanation of the TCP scheme, providing information regarding the emissions target, timescale, how the scheme would work and what this implied for the individual. Respondents were also told that the scheme had been designed to be self funding, which included an annual investment in public transport with any additional revenue being invested in measures that would support adaptation to the scheme, such as local amenities and improved cycle and walking facilities (see appendix 5 for full details). Following the explanation of the TCP scheme, respondents were introduced to bespoke software designed to record changes to travel behaviour at three points in time (2010, 2020 and 2030) and provide respondents with a visual display of their carbon consumption relative to their free carbon permit allocation in each time period. The software was originally designed for use by Bristow *et al* (2004) to record the household response to two predefined policy scenarios and the impact of technological improvements on carbon consumed from the use of personal transport. The software used in the current study calculated carbon consumption per journey entered from the 7-day travel diary. The vehicle data provided in the travel diary was used to obtain carbon emissions factors from the Society of Motor Manufacturers and Traders (SMMT,

2005) and/or the Vehicle Certification Agency (VCA, 2005) databases and entered into the software. The emissions factors provided by the SMMT/VCA databases are based on urban driving conditions, hence to represent different journey speeds, the urban vehicle emissions where factored up or down according to predefined figures within the software. For rural speeds the urban emissions factors were multiplied by 0.87 for petrol engines and 0.72 for diesel engines. To calculate motorway speeds, the urban emissions factors were multiplied by 1.16 for petrol engines and 0.89 for diesel engines (NAEI, 2005). For public transport modes and taxi services, pre-defined emissions factors already existed within the software based on 2003 data (Bristow *et al.,* 2004). In order to calculate carbon emissions for each journey, information about each journey made was entered into the software. The calculation is based on mode and personal vehicle used (where details for more than one vehicle were provided), average journey speed (urban, rural or motorway), number of people on the journey, and distance travelled**.** On separate interfaces, the software displayed carbon emissions by mode (see figure 3.6), carbon emissions per journey on a daily view which could be changed to separately show each week day (see figure 3.7), and total carbon emissions from all journeys made during the diary week. In order to maintain anonymity, the respondent's name has been changed.

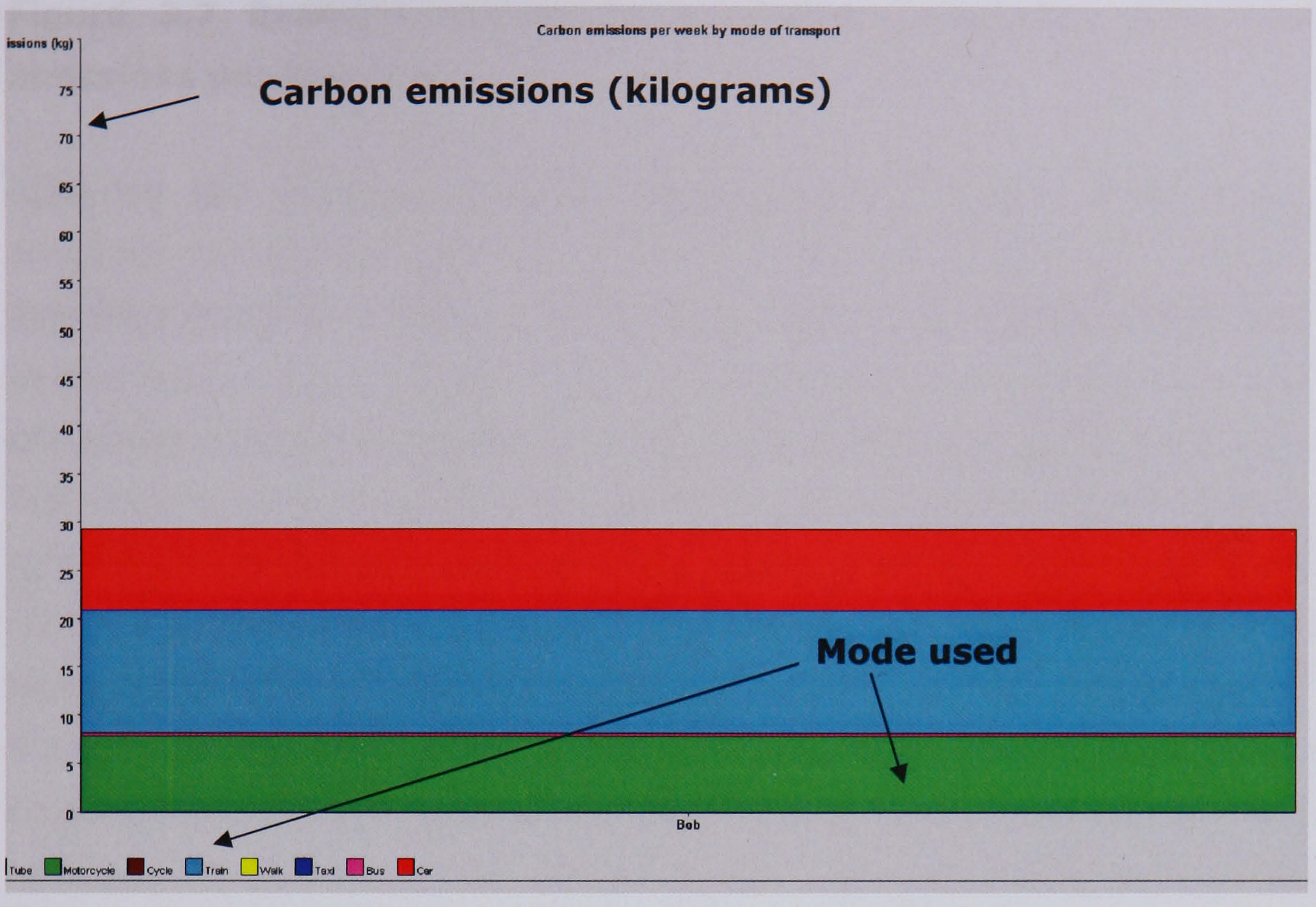

Figure 3.6: Example screenshot of carbon software: total weekly carbon emissions by mode

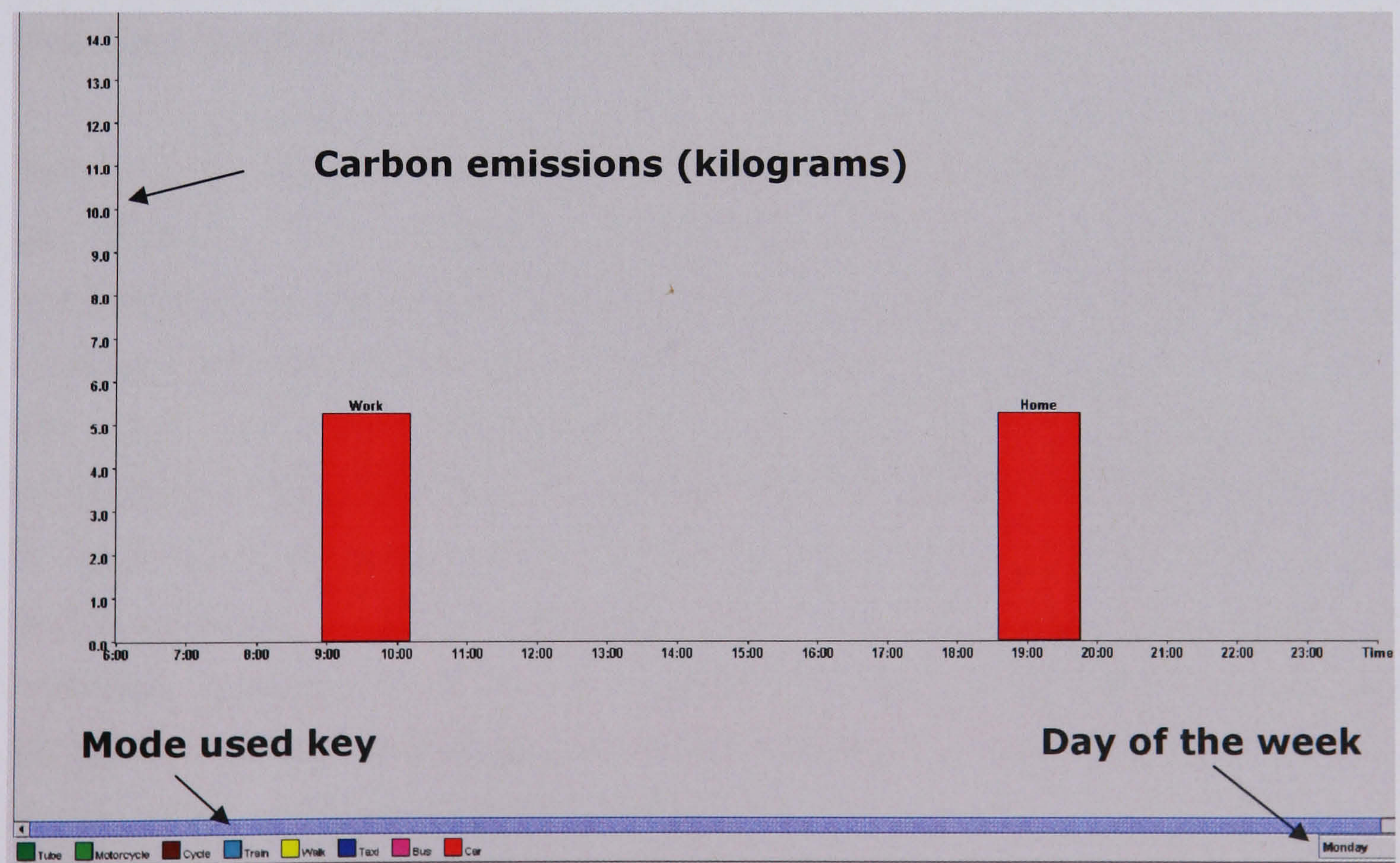

Figure 3.7 Example screenshot of carbon software: daily carbon emissions per journey

Following the introduction to the software and display of current carbon emissions calculated from the travel diary, respondents were shown their free allocation of carbon permits in 2010 (according to the derivation described in section 3.1.5 - also see figure 3.3) alongside their current carbon consumption and asked if they would make any changes to their travel behaviour should the TCP scheme be introduced. This was an open question and hence responses were not restricted to a list of options. In anticipation of some respondents choosing to replace their vehicle with a more efficient model, a list of emissions factors for the most fuel efficient models available were derived which could be entered into the software if required. Respondents were asked to assume their current circumstances in terms of employment, income and living situation remained the same as now. Where feasible, changes were made to stated journeys and carbon emissions were recalculated. This process was repeated for each time period. The details presented via the software in relation to both the TCP scheme and FPI changed following the pre-pilot study and are thus discussed in detail in sections 3.7.1 and 3.7.2.

Before introducing a policy that would undoubtedly impact on travel behaviour and lifestyles, it is imperative to investigate the likely behavioural response and subsequent impacts in order to assess the requirements, in terms of aiding response and minimising the negative impacts, at the implementation stage and thus the overall feasibility of the scheme. For example, this was recognised by Transport for London (TfL, 2003), which commissioned a survey to explore the impacts of the London Congestion Charging Scheme prior to implementation. Thus, following the questions regarding behavioural response, questions were centred upon impacts of the TCP scheme on lifestyle, barriers to change and measures to aid adaptation. Personal and social costs and benefits, personal and social (how society might rate the scheme) fairness, effectiveness (ability to achieve emissions target) where then explored, followed by personal and social (how society might rate the scheme) acceptability of the TCP scheme. As previously discussed in chapter 2 (see section 2.8), acceptability is a major determinant of policy implementation and would thus be explored prior to operation of such a scheme (Schade, 2003).

The order of questions was chosen to allow the interviewee to think about the scheme and its impacts before rating their acceptability. Steg (2003) also notes the importance of allowing respondents to consider the consequences of policy measures before evaluating their effectiveness and acceptability. Following these questions, the interviewees were asked if they would alter any aspect/s of the proposed TCP scheme in order to increase acceptability to themselves and/or to society, providing an explanation for their chosen alteration/s. They were then asked to re-rate their acceptability of the scheme, assuming that their suggested changes had been implemented.

3.6.3 Section 3: Behavioural response, impacts and acceptability of the fuel price increases

In the final section, questions were focussed on fuel price increases proposed as an alternative measure to the TCP scheme. The order of presentation of the two policies was alternated, therefore reducing the possibility of response bias that could occur if the interviews were always conducted in the same order, for example, the TCP scheme in section 2 followed by the pricing scheme in section 3. Instead, the TCP scheme was discussed first in 50% of the interviews and the pricing policy discussed first in the remaining interviews. Before the questions began, respondents were informed that, as an alternative measure to the TCP scheme, based on economic theory gained through empirical evidence on public response to fuel price increases, fuel prices could be gradually increased each year to achieve the same emissions target as the TCP scheme. Again they were told that the policy had been designed to be self funding, which included an annual investment in public transport, with the use of surplus revenue to fund supportive measures such as local amenities and improved cycle and walking facilities (see appendix 6). In order for comparisons to be made, the questions in sections 2 and 3 were identical. In the final question, respondents were asked if they thought there was a more effective way to reduce CO_2 from the transport sector, rather than the two measures discussed. This was included to allow respondents the opportunity to suggest other methods, as it was expected that pull measures, such as improvements to public transport services, would be preferable (see section 3.4).

3.7 Research process/implementation

Prior to implementation of the main survey, a pre-pilot and pilot study were conducted. The following sections describe each part of the study including the alterations made as a result of the pilot work.

3.7.1 Pre-pilot

To test the interview structure, technique and software used to record behavioral response, a pre-pilot study was conducted in July 2005, where 5 individuals were interviewed for approximately 1.5 hours each (see appendix 7 for questionnaire). Such studies are recommended as it is vital to have the interview schedule correct before the main survey is carried out in order to receive the most worthwhile information (Robson, 2002). Following this, significant changes were made to the questionnaire and software.

The first section of the interview used a quality of life ranking to assert which issues were of most importance to respondents. The question included national and international issues such as terrorism, war, crime, transport and quality of the National Health Service. However, following analysis of the pre-pilot interviews it was decided that this question was difficult to answer for most people and thus did not provide a useful measure of quality of life indicators.

As a result this question was removed from the interview questionnaire. Following this, statements were used to measure environmental concern, with responses given on a 7-point scale ranging from 'very strongly disagree' to 'very strongly agree'. Flash cards were used to display the statements and in order to minimise the risk of response bias, the statements were randomly presented in negative and positive form. The content of the statements was centered on key environmental topics such as climate change, air and water pollution, deforestation, recycling and renewable energy. A similar method was also used by Fujii *et al* (2004) to measure environmental concern. Several statements were altered following the pre-pilot in order to include an equal number of positive and negative questions. Problem perception was measured using an open question regarding problems that respondents associated with current levels of road transport. This question was considered useful and therefore remained unchanged following the pre-pilot. Respondents were then asked to rate on a scale of 1 – 7 the contribution made by road transport to 6 environmental issues including global warming, destruction of wildlife habitats and water pollution. Following the pre-pilot it was decided that more specific questions were required in order to assess levels of knowledge, hence a new question was devised which asked respondents the percentage contribution (within 20% bands) of road transport to total UK emissions, including carbon dioxide, carbon monoxide and particulates. The final questions in section 1 regarding the association of pollutants and health effects with road transport were considered too general and did not yield useful information (the majority of respondents answered 'no' to both questions) and were therefore removed from the questionnaire.

Section 2 began with an explanation of the TCP scheme followed by the software (as described in section 3.5.2). Respondents were shown their free allocation of carbon permits in 2010, 2020 and 2030 and asked if they would make any changes to their travel behaviour. Figure 3.8 provides an example of carbon consumption and free carbon permits in each time period.

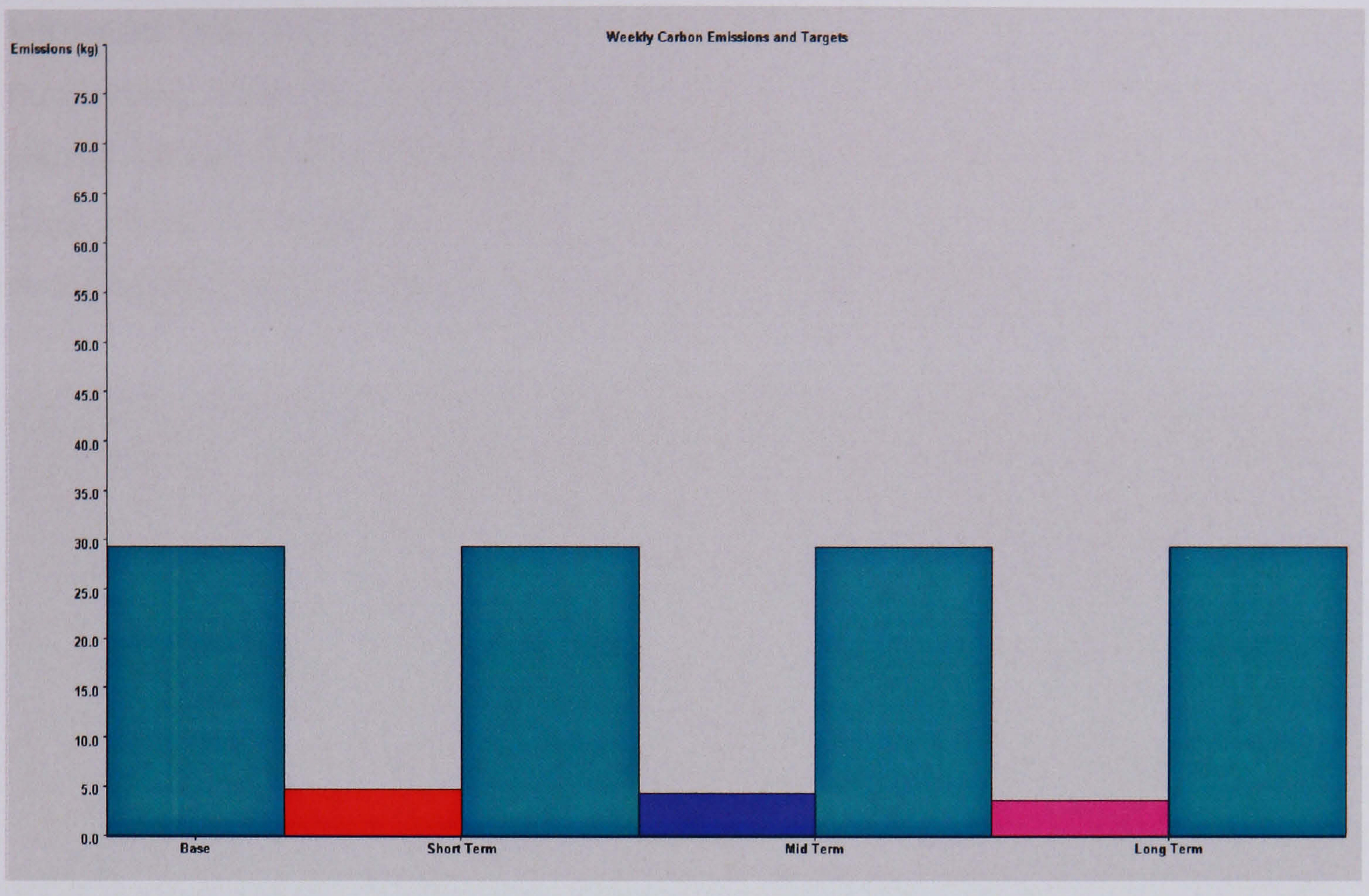

Figure 3.8: Carbon consumption and free permit allocation

Figure 3.8 notes: from left to right – current consumption calculated from travel diary; free permit allocation in 2010; carbon consumption in 2010; free permit allocation in 2020; carbon consumption in 2020; free permit allocation in 2030; carbon consumption in 2030.

During the software exercise several respondents asked how much the permits would cost (in monetary terms), therefore following the pre-pilot it was considered necessary to provide an estimation of permit price hence estimated financial costs and corresponding permit prices were derived (described in sections 3.1.9 and 3.1.10). The software was adjusted to include an estimate of current spending on fuel (based on the average litre of fuel containing 0.62 kilograms of carbon) and fuel and permits in each time period displayed as 'to pay for' which was the difference between the free permit allocation and consumption. This provided respondents with an indication of the monetary impact and the effect on their carbon consumption of the changes they considered to be feasible. The software was able to recalculate estimated spending when changes to travel behaviour were made. Respondents were informed that the prices derived by the software did not include inflation or fluctuating oil prices and that the permit prices displayed were based on fixed permit prices and could increase unlimitedly if sold on an open market were they would be subject to demand. Figure 3.9 shows an example of carbon consumption and estimated spending in each time period.

Figure 3.9: Screenshot of carbon consumption and free permit allocation post pre-pilot

Notes for figure 3.9: from left to right – current consumption and spending on fuel; free carbon allocation in 2010; carbon consumption in 2010 with estimated spending on fuel and permits; 2020; 2030.

In the pre-pilot study, software was only used when discussing the TCP scheme. Thus for consistency, following the pre-pilot, the software was redesigned to represent the FPI. Respondents were again shown their current carbon consumption with estimated spending on fuel and also their carbon consumption in 2010, 2020 and 2030 with estimated spending on fuel taking into account the price increase as a result of the FPI (see figure 3.5 and appendix 2 for fuel prices used in the software). Figure 3.10 provides an example of the software representing the FPI.

Figure 3.10: Screenshot of the FPI post pre-pilot

Notes: from left to right – current carbon consumption and spending on fuel; carbon consumption in 2010 and estimated spending on fuel; 2020; 2030.

Following the software exercise, respondents were asked an open question regarding how they would adapt in the long-term. However, this was largely a repeat of the behavioural changes recorded with the software and was thus recreated following the pre-pilot study into a quantitative style question where respondents indicated on a scale of 1 to 7 their likeliness of carrying out stated behaviours, including moving house to live closer to work and telecommuting, in the long-term i.e., beyond 2030. In recognition of the importance of fairness on acceptability (Jakobsson *et al.,* 2000; Fujii *et al.,* 2004), a question designed to provide a measure of perceived fairness of both policies was added following the pre-pilot. In addition, as the policies were discussed separately throughout the interview and not directly compared, 2 open questions were added to the end of the questionnaire which were designed to provide a direct comparison of the policies in terms of effectiveness and acceptability.

The pre-pilot revealed that some of the questions were resulting in repetitive answers. For example, a question regarding the role of the government, fuel producers, and vehicle manufacturers in the policies was removed as most respondents had already talked about this when discussing their behavioural response. In addition, many respondents found the question difficult to understand which is undesirable in terms of maintaining interest over the period of the interview.

3.7.2 Pilot study

Following the extensive changes arising from the pre-pilot study, a pilot study was conducted between September 2005 - November 2005 (see appendix 8 for interview questionnaire). Ten people were interviewed, which served to test the recruitment technique, modified interview questionnaire and software before the final survey was conducted. The pilot revealed very few problems with the whole interview process, with the only changes being the reordering of two questions, the merging of the costs and benefits questions into one question and the amendment of the knowledge question in the first section of the questionnaire. For the pilot, the knowledge question asked respondents to state the percentage contribution (within a range) of road transport to five key pollutants. However, it was noted that many respondents were guessing rather then basing their answer on their actual knowledge. It was therefore decided to redesign the knowledge question using 10 statements regarding transport and environmental facts that could be answered as 'true', 'false' or 'not sure'. It was thought that respondents might have greater awareness of wider transport issues rather than the percentage contribution of road transport to air pollutants, given the specialist nature of such knowledge (see appendix 5 for main survey questionnaire). Given the nature of the policy targets, an additional measure of problem perception related to climate change was included. Using an open question, respondents were asked if they considered global warming to be a serious threat, whether the problem was human induced and if it could be reduced.

Following the analysis of the pilot results, it was noted that the average rating of effectiveness of the TCP scheme was lower than expected, given the potential to be 100% effective as a result of the limit placed on carbon availability. It therefore seemed apparent that respondents had possibly not fully understood the concept of the TCP scheme, in terms of achieving the emissions target through the limit placed on availability. Several respondents appeared to forget about the carbon budget and thought that people would buy additional permits when required, for example:

"People will just buy more when they run out. They won't care about sticking to the limit".

This implies that an unlimited amount of permits would be available and achieving the target would be reliant on the publics' good will to reduce their fuel consumption. In an attempt to correct this, it was decided that the limit on carbon availability should be made very prominent during the behavioural response section when the software was introduced. When discussing each time period, respondents were asked if they would make any changes to their travel behaviour and whether they would try to consume within their free permit allocation or buy extra permits as required if they were available. It was explained to respondents that their free allocation of carbon permits would be their only guaranteed source of carbon, hence beyond this carbon availability would be uncertain, with the possibility that they might not be able to purchase any more permits. The reduction in the amount of carbon allocated each year was also highlighted using the software.

Two questions related to the inclusion of air transport in the TCP scheme and FPI (support and whether current use of air transport would be altered) were added following the pre-pilot. Whilst the policies were based on road transport, it is recognised that carbon emissions from air transport are the fastest growing source (DEFRA, 2007), thus it could become imperative to regulate emissions from this sector. Whilst the UK government are currently proposing to include aviation in the EU ETS (as explained in chapter 2), instead it could be possible (and possibly preferable amongst the public) to include aviation in a personal carbon trading scheme. Hence, the questions were included to provide some public perspective.

During the pilot it was noted that many of the responses to the open questions were very similar and could thus be grouped into categories. Hence, for the main survey, the categories identified during the pilot were included in the main survey questionnaire in order to aid analysis (they were only visible to the interviewer and were thus not provided as options for the interviewees). Extra space was also provided in order to record responses that did not fall into the categories listed.

3.7.3 Main survey

From February 2006 to May 2006, 60 people were interviewed, with each interview lasting approximately 1 to 1.5 hours. The original aim was to conduct 90 interviews, based on three main sub groupings with each requiring a minimum of 30 people to allow a full statistical analysis to be conducted. The main factors perceived to influence acceptability were narrowed into two categories: knowledge (problem perception, environmental awareness, knowledge of transport issues and the ability to understand explanation of TCP scheme), and travel consumption (level of inconvenience and costs and benefits posed by TCP scheme). Both of these categories could be divided into three sub groups to test relationships with acceptability. For education, these groups would be basic (G.C.S.E standard), further (further education, A level standard), and high (higher education - degree level and above). Travel consumption could be segregated by low (below average), average, and high (above average) groupings. The aim was to make comparisons between responses by separating the data into the categories described. However, the working design of the TCP scheme required more time than anticipated given the need for the scheme to be detailed and realistic and thus presentable to the public. The extensive changes to the software (which required the derivation of estimated costs for the TCP scheme - see section 3.1.4) and questionnaire following the pre-pilot, greatly reduced the amount of time available for recruitment, interviewing and data analysis. In addition, as the questionnaire developed the interview duration increased to almost 3 times the original estimate of 30 minutes (this was also based on the original aim of the interviews which was to investigate attitudes only towards the TCP scheme before the scope of the study was expanded to necessarily include the FPI). However, this resulted in a much richer data set, with in-depth qualitative and quantitative responses to the majority of key issues regarding both policies. Delays were also encountered during the recruitment and interview process, including several respondents dropping out after having their diary data entered into the software and many cancelling and rearranging interviews. Thus, the sample size was reduced to 60 as a result of time availability.

Many road pricing studies have selected particular groups that would be affected by road pricing, such as urban dwellers and motorists (for example, Jakobsson *et al.*, 2000; Whittles, 2003; Schade and Schlag, 2000). However, as everyone would be affected by the TCP scheme, it was considered important to recruit a varied sample which included urban and rural dwellers; and motorists and non-motorists. A selection process was therefore established. A screening questionnaire was completed by all interested parties (see appendix 9) taking into account demographic criteria such as travel consumption (annual car mileage), car availability, gender and place of residence (urban, rural). This method was also used in the AFFORD study (Schade and Schlag, 2000; Schade and Schlag, 2003). It was recognised that a small sample would not be representative of the UK population, therefore the employed population were selected as the focus for the study as they tend to consume the most travel

(DfT, 2005b), and would therefore have to make the greatest changes in response to the policies. Thus, staff members from two of the largest employers in Leeds - the University of Leeds and the Leeds City Council, were recruited via an email that provided a brief explanation of the study, details of participation and offered a small monetary reward on completion of the survey.

Table 3.2 displays the main stages of the survey, from recruitment to interview completion, with response rates at each stage.

Table 3.2: Response rates at all stages

Activity	Number completed	Response rate
Stage 1:		
Emails	1014	11.4%
Responses	116	
Stage 2:		
Screening questionnaires sent	116	9.3%
Screening questionnaires returned	94	
Stage 3:		
Diaries sent	94	6.9%
Diaries returned	70	
Stage 4:		
Diaries returned	70	5.9%
Interviews completed	60	

Whilst the response rate at stage 1 is very low in comparison with similar public surveys (e.g., Jakobsson *et al.*, 2000), the method used was much less resource intensive than recruiting via post or on-street, thus offsetting to an extent the low overall response rate of 5.9%. In addition, email contact appeared to be the most suitable choice given the extensive email network at both the University of Leeds and the Leeds City Council. However, in consideration of the high level of commitment and input required from respondents, a low response rate was anticipated hence the large amount of emails originally sent at stage 1. In addition, it was expected that a proportion of the emails sent would not be viewed. Such problems were encountered by Shannon *et al* (2006) who decided not to use email contact to recruit participants again following the uncertainty regarding the number of emails that were actually read, thus making the response rates difficult to estimate at the beginning of the recruitment process. Groot and Steg (2006) used emails to recruit participants to complete an internet survey, however they asked email recipients to forward the internet survey link to as many people as possible. Whilst this method was successful for Groot and Steg (2006), achieving a sample size of 490 people, this 'snowball' method was unsuitable for the current study given the strategic targeting of the employed, mostly car using population. The response rate could have possibly been improved by advertising the study in internal news letters around departments across the university and city council. This method was used by Kingham *et al* (2001) who recruited employees at two UK companies via internal news letters and emails, achieving a response rate of 38% and 42%. However, the study involved the completion of a post back questionnaire which is much less time consuming in comparison to the completion of a 7-day travel diary and attending an interview, therefore even with the addition of internal adverts in the current study, comparable response rates would not be expected.

Response rates could have been increased if the interviews were conducted using the telephone. For example, Jensen achieved a very high response rate (79%) when conducting telephone interviews. However, in the current study it was imperative to conduct the interviews face to face as the policies were visually represented using the low carbon software (see sections 3.5.2 and 3.6.1). Recruitment via post typically provides a response rate of around 15%, thus it is possible that the response rate would have been higher if initial contact was made through post instead of email. However, Brand *et al* (2006), achieved a higher response rate to an internet survey (23.4%) than a postal survey (19%) conducted as part of the same study (the questionnaires were identical).

Table 3.2 shows a low drop out rate from stage 2 of the study onwards (19% at stage 2, 23% at stage 3 and 14% at stage 4). Hence, when a person had shown their interest by replying to the initial emails they were quite likely to continue to the end of the study with a 64% completion rate from stage 2 to stage 4. This has also been discovered in other studies, for example Shannon *et al* (2006) contacted potential participants via post inviting them to complete an internet survey with an overall response rate of 49%. Rienstra *et al* (1999) also achieved high response rates by conducting a survey in stages, with potential respondents being initially sent an invitation by post to state their interest in completing a questionnaire, achieving a response rate of 25%. Of those that replied, 53% completed the questionnaire.

Table 3.3 details the characteristics from the main sample.

Table 3.3 Sample characteristics

Variable	Respondents	UK average
Female	63%	51.2%
Age (years)		38.6
18 - 35	53%	
36 - 53	37%	
>54	10%	
Education		11% of population
Basic	7%	has higher education
Further	18%	qualifications
Higher	75%	
Gross household Income/annum		£28, 000
<£10, 000 - £20, 000	27%	
£21, 000 - £40, 000	38%	
>£40, 000	35%	

Car availability		72% households have access to 1 or more cars
0	17%	
1	53%	
2+	30%	
Annual car kilometres		8,796 km/person
Below average (>0 - 8,000)	39%	
Average (8,000-9,000)	14%	
Above average (>9,000)	47%	
Sample average: 12,064 km/person		
Average distance per mode of transport (km)[7]		
Car	232	178
Bus	28.7	10.9
Train	80.2	14.2
Motorcycle	1.1	1.1
Taxi	1	1.8
Cycle	4	1.1
Walk	5.5	6.1

The sample was over representative of females and younger age groups, with the majority of the sample aged below 35 years old. People with higher education were also over represented as only 11% of the UK population has higher education qualifications (ONS, 2001). However, the small sample size should be considered, in addition to the strategic targeting of the employed sub-population, hence it was expected that the sample would above average in terms of education. The majority of the sample were earning above the UK average income (ONS, 2001), which again was anticipated given the method of recruitment. As intended the sample exhibits higher than average car use and

7 For the travel week recorded in the 7-day diaries. The UK figures are derived from Transport Statistics (DfT, 2006a) provided in distance traveled per person per mode per year, which were thus divided by 52 to obtain a weekly figure and multiplied by 1.609 to convert from miles to kilometres. The data used in Transport Statistics is collected through the National Travel Survey, which is an annual survey using 7-day travel diaries to record personal travel.

car ownership. Car availability was 11% higher than the national average, which was expected to be higher still given the above average income levels. In addition, in comparison to the national average, the sample travelled almost 6 times further by train, more than twice as much by bus, and almost 4 times as much by cycle, whilst walking and taxi use amongst the sample was below the national average. The higher than average use of public transport was not anticipated and could possibly result in fewer responses in terms of behavioural change, in particular changing from car to bus and/or train. This is discussed in more detail in chapter 5 together with the results recorded by the low carbon software (see sections 3.6.2 and 3.7.1).

Chapter 4

Concern for the environment, knowledge and problem perception

This chapter provides the responses to the attitude measures and questions contained in the first section of the interview questionnaire. Hence, this chapter serves to provide the sample characteristics in terms of concern for the environment, knowledge of transport issues and problem perception. All data shown is based on the full sample of 60 respondents. Quotations taken directly from the interview discussions are included to provide examples of responses to open questions - at the end of each there is a respondent identification number in brackets which corresponds to the list of respondents given in appendix 10.

4.1 Concern for the environment

As explained in chapter 3 (see section 3.6.1), respondents were asked to state their concern towards a range of environmental issues. To derive an average 'score' of concern, the responses were subsequently given a score of 1 to 7 with 7 represented the highest concerned for the environment and 1 the least concerned. Figure 4.1 below shows the averaged scores for each respondent. The respondent numbers correspond to those provided in appendix 10.

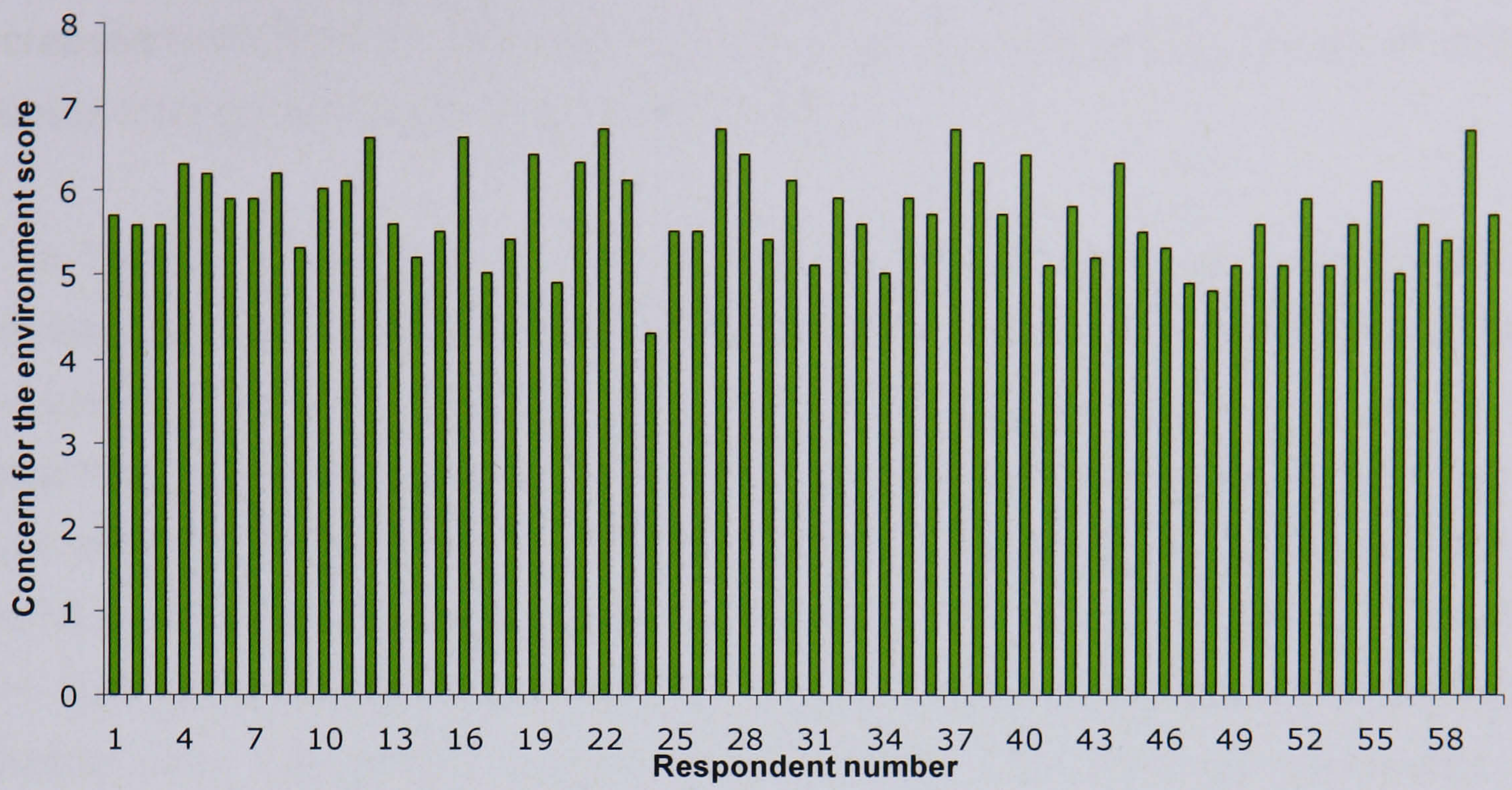

Figure 4.1: Concern for the environment – average scores

Figure 4.1 shows that all respondents were concerned for the environment to some degree, with the majority of scores above 5. Overall, the sample had an average score of 5.7 (maximum score = 7), thus on average respondents were very concerned about the environment. A Cronbachs Alpha test was used to measure the internal consistency of the concern for the environment question. Cronbachs Alpha is designed to measure the reliability of psychometric instruments and will increase towards 1 when the correlations between items increase (Coolican, 1999). Each environmental statement was classed as an item. The test provided a score of 0.76, therefore indicating an adequate degree of internal consistency that is comparable with other studies measuring environmental concern (Weigel and Weigel, 1978; Dunlap *et al.,* 2000; Walton *et al.*, 2004).

The level of concern for the environment across the sample is consistent with other findings. For example, in a survey conducted by DfT (2006c), 84% of respondents were very or fairly concerned about environmental issues and 81% were very or fairly concerned about climate change. In addition, the results suggest that the level of concern is increasing, for example between

2005 and 2006 the proportion of adults very concerned about the environment increased from 26% to 31% and the proportion of adults very concerned about climate change increased from 48% to 54%.

A correlation analysis was conducted in order to explore the relationships between concern for the environment and the socioeconomic variables shown in table 3.6. Given the categorical nature of the majority of the variables, a Spearman's rank correlation was selected as the most appropriate method as it does make any assumptions regarding the frequency distribution of the data, hence it does not assume that the relationship between the variables is linear. The test also measures whether the relationships are significant and hence whether the correlation occurred by chance. The test also provides a correlation coefficient which shows the strength of the relationship, with a value of 1 indicated a perfectly correlated relationship. Concern for the environment was revealed to have a positive and significant ($p<.05$) relationship with age. The following tables show the average levels of concern for the environment for each category of the socioeconomic variables measured.

Table 4.1: Average levels of concern for the environment split by gender, age, income and education

Variable		Concern for the environment score
Gender	Male	5.76
	Female	5.69
Age	18 - 35	5.58
	36 -53	5.82
	>54	6.03
Income	<£10, 000 - £20, 000	5.76
	>£20, 000 - £40, 000	5.67
	>£40, 000	5.74
Education	Basic	5.93
	Further	5.93
	Higher	5.65

In terms of gender, males and females had very similar levels of concern for the environment with slightly higher levels amongst men. The average levels of concern amongst the different age groups demonstrate the positive relationship identified by the Spearman's rank correlation, with concern increasing with age. This was also a finding by the DfT (2006c), where the number of people fairly concerned or very concerned about the environment increased with age.

The income data shows that concern was highest amongst the lowest income group, with very similar levels in the highest income group. The DfT (2006c) also found little variation in levels of concern across income groups. In terms of education, concern was lowest amongst the most educated group. Conversely, the DfT (2006c) found that concern about the environment was lowest amongst those with the lowest levels of education. It is possible that the sample characteristics are having an effect as the majority of respondents had higher education qualifications.

4.2 Problem perception

On average, each respondent stated 2.6 problems associated with current levels of road transport, the main problem being congestion, with air pollution and safety being the next most commonly mentioned problems. These findings are consistent with those reported by CfIT (2002), where congestion was the most commonly mentioned transport issue. In addition, congestion was rated as the most important issue from a list of 23 transport related problems. Vehicle pollution affecting health and road safety were rated as the next most important issues after congestion.

The majority of respondents stated 2 problems that they associated with current levels of road transport. Figure 4.2 shows the total amount of problems stated by each respondent.

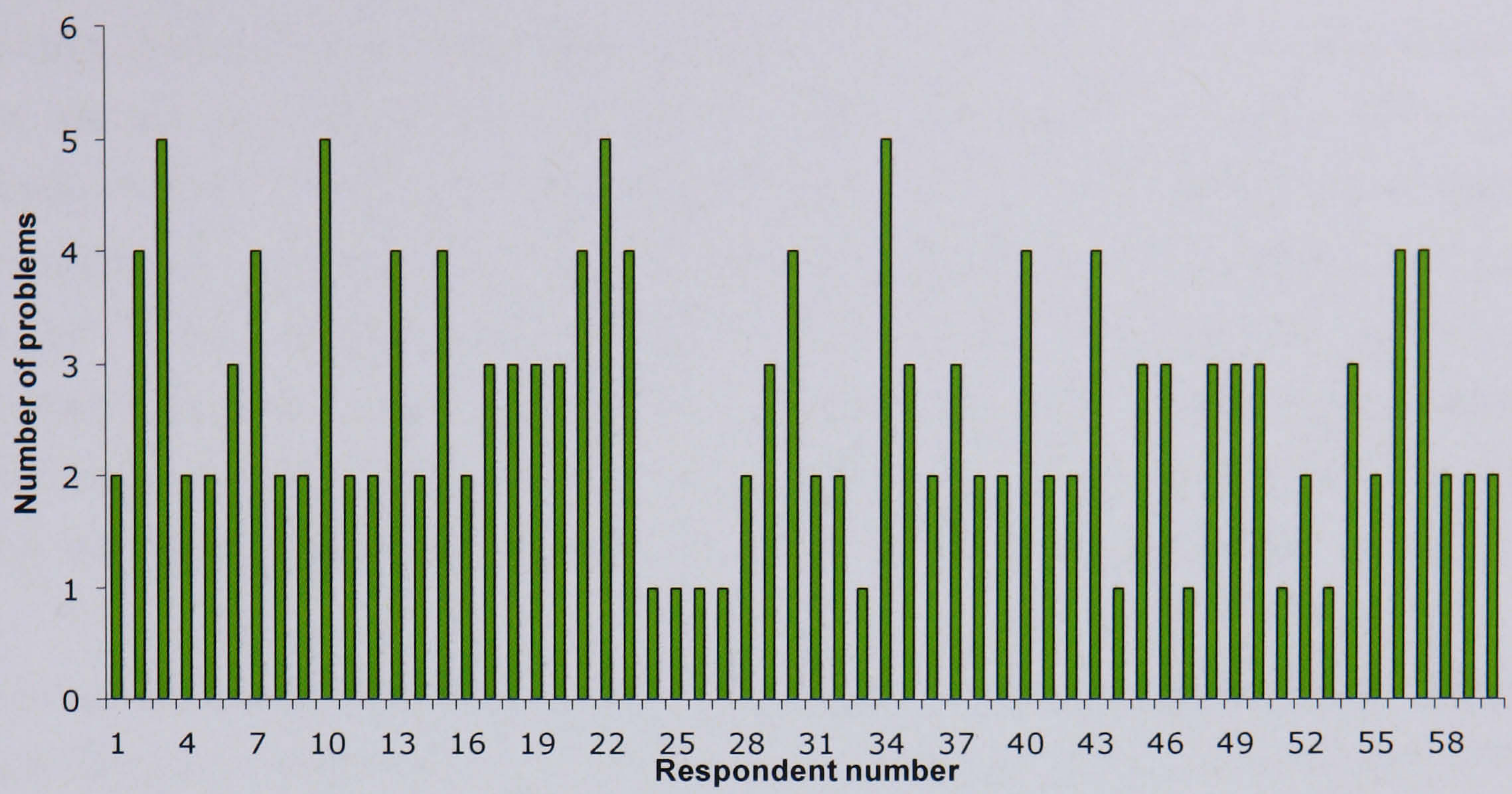

Figure 4.2: Number of problems stated by each respondent

A Spearman's rank correlation did not reveal any significant relationships between problem perception and the socioeconomic variables. Table 4.2 shows the average level of problem perception amongst the sample (number of problems mentioned) for each category of gender, age, income and education.

Table 4.2: Average levels of problem perception split by gender, age, income and education

Variable		Problem perception
Gender	Male	4.05
	Female	3.68
Age	18 - 35	3.97
	36 -53	3.41
	>54	4.50
Income	<£10, 000 - £20, 000	3.19
	>£20, 000 - £40, 000	3.87
	>£40, 000	4.25
Education	Basic	2.25
	Further	3.45
	Higher	4.05

On average, males mentioned a greater number of problems associated with current levels of road transport in comparison to females. The respondents in the highest age group had the highest level of problem perception across all variables and categories. The income data shows that problem perception increases as income also increases, which could possibly be related to car use as which also increases with income (DfT, 2006b). It is logical that more problems would be perceived and/or identified as levels of driving increased. The table also shows that problem perception increases as education levels also increase. This is also likely to be a result of income and car use.

During the first section of the interview respondent were also asked (unprompted) whether they thought global warming was a serious threat. 93% of the sample considered global warming to be a serious threat, whilst only 7% were unconvinced:

"*I don't think so, most of what you hear is just media hype trying to scare people* (24)" and "*I'm not convinced about global warming, global temperatures go up and down naturally so I don't think it's something new that we're causing* (16)" and "*Definitely, I think everyone should be thinking about it. We need more evidence but we should do something about it anyway. The ice caps are already melting* (49)".

The Royal Society for Arts (RSA, 2006) found similar results from a public attitudes survey, where 84% of respondents agreed that 'climate change is a real problem and we all need to do something about it'. Research conducted by Norton and Leaman (2004) revealed that most people had heard of global warming and it had become a commonly used and heard term amongst the public, with 67% of respondents feeling that they knew 'a great deal' about it. Professional and managerial groups were more likely to consider global warming as a serious threat compared with other social classes. This could explain the response from this sample, given that the majority of respondents had professional roles.

A number of respondents felt that human activity was either partly or wholly responsible for global warming:

"I do think it's a threat and I think we're causing it (50)" and *"I think we're definitely contributing to it but it's also part of a natural cycle* (3)".

A study conducted by MORI (2007) revealed that 42% of respondents considered human activity to be either partly or fully causing global warming. Only 11% of respondents thought that climate change was a result of natural causes alone.

4.3 Knowledge of transport issues

A list of 10 individual statements regarding the environmental and health impacts of transport were presented with the options 'true' 'false' and 'not sure'. Scores were then calculated for each respondent, with an average score of 3.8 from a maximum score of 10, thus indicating a fairly low level of knowledge amongst the sample. The majority of respondents had a score of 3, however, several respondents had a knowledge score of 0, thus reducing the overall group average. Figure 4.3 shows the scores for each respondent.

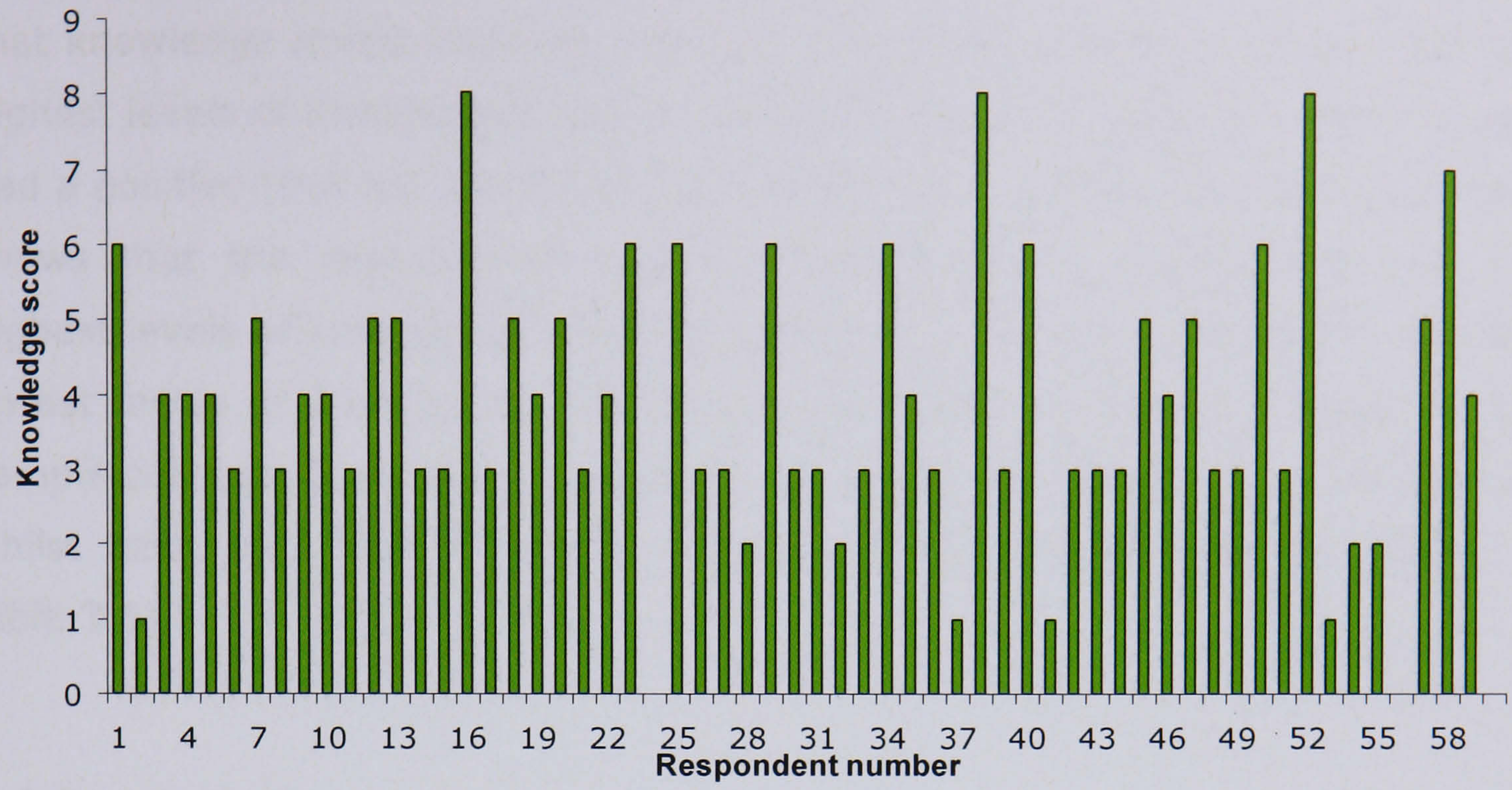

Figure 4.3: Knowledge score for each respondent

A Spearman's rank correlation did not reveal any significant relationships between knowledge and the socioeconomic variables. Table 4.3 shows the average level of knowledge amongst the sample for each category of gender, age, income and education.

Table 4.3: Average levels of knowledge split by gender, age, income and education

Variable		Knowledge score
Gender	Male	2.77
	Female	2.59
Age	18 - 35	2.52
	36 -53	2.82
	>54	2.83
Income	<£10, 000 - £20, 000	2.69
	>£20, 000 - £40, 000	2.57
	>£40, 000	2.75
Education	Basic	2.75
	Further	3.09
	Higher	2.55

Males had a slightly higher level of knowledge than females. The data shows that knowledge levels increase with age. The highest income earners had the highest levels of knowledge, which is possibly related to age particularly as age had a positive (but not significant) correlation with income. The education data shows that the respondents with further education qualifications had the highest levels of knowledge whilst those with the highest qualifications had the lowest levels of knowledge. However, these results could be a result of the sample characteristics given that higher education was very overly represented whilst basic and further education were underrepresented (see chapter 3 - table 3.6).

4.4 Conclusions

The results revealed that males had a higher level of concern for the environment, problem perception and knowledge in comparison to females. Overall, respondents aged over 54 years had the highest levels of concern for the environment, problem perception and knowledge in comparison to all categories of the socioeconomic variables. The majority (83%) of respondents in this age group were male which could therefore largely explain the differences revealed between genders.

The results have shown similarities with other research, particularly in terms of concern for the environment and problem perception. It is recognised that some of the findings, particularly in relation to the perception of global warming, could be sample specific in terms of the characteristics amongst respondents with the majority being highly educated and above average income earners.

Chapter 5

Survey results: behavioural response to the Tradable Carbon Permit scheme and fuel price increases

This chapter analyses the travel data collected by the low carbon software described in chapter 3. Section 5.1 shows the stimulus (fuel prices and free permit allocations) that people were responding to. Section 5.2 explores those who did not change their behaviour, followed by the types and level of behavioural response in section 5.3. The impact of response is examined in section 5.4, in terms of kilometres travelled and carbon consumption. Section 5.5 then explores policy effectiveness in terms of achieving their carbon reduction targets. Following this, behavioural response is examined in terms of exploring relationships between those who changed and those who did not change. Section 5.7 gives an indication of behavioural response beyond 2030, with chapter conclusions provided in section 5.8. Quotations taken directly from the interview discussions are included to support the findings and demonstrate the variation in opinions.

5.1 Price signals and free carbon permit allocation

Table 5.1 displays the actual prices shown to respondents using the low carbon software for each scheme and time period. As explained in chapter 3, the price increases relating to the TCP scheme are purely a result of increasing permit prices over time (as explained in chapter 3 – see sections 3.1.9 and 3.1.10), whereas elasticities of fuel demand were applied to derive the necessary price increases in the FPI policy (as detailed in chapter 3 - see section 3.2).

Table 5.1: Fuel price (pence) and % increase from base[8] in each time period for the TCP scheme and FPI

Year	Fuel price/litre TCP scheme	Fuel price/litre FPI	% increase TCP scheme	% increase FPI
2010	88.2	90.7	3.8	6.7
2020	96.7	106.8	13.8	25.6
2030	115.2	137.4	35.5	61.6

The free permit allocation was displayed on screen to enable respondents to compare their own carbon consumption with the amount of carbon they would receive free of charge under the TCP scheme. In 2010, the free permit allocation equated to 4.4 kilograms of carbon per person per week, decreasing to 3.8 kilograms of carbon per person per week in 2020 and 3.1 kilograms of carbon per person per week in 2030. Displaying the free allocation allowed respondents to judge how many additional carbon permits they would require to meet their consumption and/or how many excess carbon permits they would have. Displaying the free carbon permit allocation also allowed respondents to see the impact of any changes to their travel behaviour in terms of the difference between their carbon consumption and their free permit allocation. Estimated spending on fuel and permits was also displayed in each time period (including base).

For the FPI, the estimated price of carbon consumption (in terms of fuel) was shown on the screen. In each time period, respondents where shown the estimated price of their carbon consumption without any changes from their base consumption (the cost increased in each time period according to the prices shown in table 5.1).

8 Base fuel price = 85p per litre for both the TCP scheme and FPI.

5.2 No behavioural change

The majority of respondents (37) would not make any changes in response to either scheme in any time period, although 26 of these people were consuming within their free permit allocation during one or more time periods and hence did not need to change in response to the TCP scheme. This group would mainly opt to either keep their excess permits for leisure trips, give them away to friends and/or relatives, or sell them to the national permit market if the price was high enough. This suggests that a large amount of trading of unused permits could occur between friends and relatives rather than sales to the public market. Others that were willing to sell their permits to the national market were likely to wait until the market price increased to provide a substantial profit. This has implications for permit availability - if unused permits are being stored, demand would quickly increase resulting in increasing permit prices, at which point the stored permits are sold. It is likely that some permits would remain in storage until the permit price increased further, thus resulting in a fluctuating market with periods of low availability and high price followed by an influx of stored permits and lower permit prices. Several respondents that did not travel by car stated they would keep their free permits unused to avoid them being used by car users, for example:

"I think I'd keep my permits, I wouldn't want someone who drives 50 miles to work and back everyday to buy them and it would save even more carbon if I didn't sell them (36)*"* and *"I'd only sell them to someone who I knew genuinely needed to use their car, I wouldn't sell them to someone so they could drive their kids to school* (50)*"*.

Hence there could be unused permits each year which would have an impact on demand, particularly prior to carbon reduction adjustments i.e. in the short term. The impact on permit demand could be reduced by releasing more permits each year than the amount corresponding to the carbon cap, assuming that a certain proportion would remain unused. However, there is a risk with this method – the emissions target could be exceeded if the additional permits were actually sold rather than unused.

It is likely that those consuming within their free carbon permit allocation did not respond to the FPI because their consumption was low, hence the price increases could be absorbed. In addition, many respondents felt that their car use was already minimal and could therefore not be reduced. The respondents that were consuming over their free permit allocation but did not respond to either policy (11 in total) largely felt that their car use was essential and could not be reduced, the journeys they made could not be made by other modes, using public transport would be inconvenient, expensive, increase journey times and reduce their choice of journey origin, destination and travel times. These respondents felt that the car provided them with options and convenience that they were unwilling to substitute and instead would prefer to pay the additional costs. Over half (7) of these respondents were above UK average carbon consumers. Steg (2005) suggests that high car usage results in a high attachment to car use and increased reluctance to change, which appeared apparent amongst the respondents that were unwilling to change despite a high potential to do so given their high consumption of carbon. However, a higher consumption does not necessarily make it easier to change. For example, a lack of alternative options could have prevented a response. Such responses suggest that utility or welfare maximisation does not always involve avoiding excessive monetary costs, although it is highly possible that other activities would be forgone in order to continue current spending on fuel without causing additional expenditure overall. For example, certain leisure activities could be substituted. Whilst this was not discussed as a behavioural response while the software was in use, later in the interview a number of respondents mentioned the possible need to sacrifice certain activities and/or journey types in order to avoid additional expenditure. This is discussed further in chapter 6 (see section 6.1).

A multidisciplinary approach to travel behaviour analysis would suggest that psychological motives including instrumental (convenience and comfort), affective (attachment to car and pleasure of driving) and symbolic reasons (car use represents wealth and social status) can be more important than monetary considerations when prices are increased (Steg, 2005; Anable, 2005). Thus, it is possible that those respondents unwilling to change and consuming above their free permit allocation possibly had psychological motives which were stronger than their monetary cost minimisation motives. However, without further investigation of attitudes it is not possible to identify which motives were most important, although from the interview discussion in some cases it is possible to identify certain motives:

"I wouldn't change my vehicle until there was an economy range car that offered me the same comfort as my current car. You don't get leather seats and the room in an economy car. The hybrids look really ugly don't they, I like my car so I'd be very reluctant to change it. No, I'd just have to buy more permits somehow or do more car sharing with my wife and work at home more I suppose (55)*".*

These comments demonstrate strong affective and symbolic motivations for car use. Anable (2005) identified such car users through a process of attitude measurement and suggests that different policies should be applied depending on motives for car use. Hence, as also suggested by Stradling *et al* (2000), a pricing policy is very unlikely to be effective where affective and symbolic motives are strong, which is possibly more of an issue for the effectiveness of the FPI than the TCP scheme given the cap on carbon availability. However, strong motives for car use could result in pressure to increase carbon availability which if implemented, could be disastrous for the credibility and effectiveness of the TCP scheme.

Several respondents felt that the impact of reducing their own car use would be insignificant in global terms. Many were sceptical that others would reduce their car use, particularly in relation to the FPI, and were thus unwilling to be disadvantaged if other people were not and no benefits would be gained from their actions:

"Why should I waste my time getting the bus if no one else is? (23)*".*

Two respondents were sceptical about the impact of both policies in terms of global emissions:

"Even if it worked and people gave up their cars it wouldn't make any difference to global emissions – what about America and China? They won't even sign up to the Kyoto. They need this more than us but we'd be losing out while they're still driving around as much as they like (51)*".*

This clearly demonstrates a need for information regarding UK carbon emissions and the importance of reduction. For example, by revealing carbon emissions per person, the UK is much higher than China. It also suggests that people need to trust that others will also cooperate, which was also shown by Anable (2005). This is possibly more of an issue for the FPI, given the lack of a limit on fuel availability in comparison to the TCP scheme which has an absolute cap on carbon availability. Whilst the respondents' observations are valid, they should not constitute a reason not to act or provide a 'get out clause'. Such issues are also explored in the following chapter in relation to the perceived fairness of both policies (see chapter 6, section 6.3).

5.2.1 Car dependency and lifestyle related barriers

Many of the respondents that did not make any changes largely felt that their current lifestyles were dependant on car use which could therefore not be reduced or substituted for another mode:

"I just couldn't use the train, I've tried it before and I nearly quit my job because it was so stressful. My life's stressful enough already without having to use the train. By the time I dropped the kids off and got to work I'd be so stressed out and then knowing that I had to get back to pick them up, I just couldn't do it, no. The only thing I could do is car share with my husband who also works in Leeds, although that wouldn't always be possible as we work different hours so I'd have to drive most days anyway. I think there'd have to be a permit allocation for children, otherwise I might have to give up my job (42)*"* and *"I'd like to not have to drive in everyday in all that traffic but it'd take me too long to get the train* (3)*"* and *"Public transport just isn't good enough* (7)*"*.

It is possible that some of the responses were excuses for continuing current car use rather than actual barriers to change - it is much easier to say that public transport is not an adequate alternative to car use than to actually transfer car trips to public transport. In addition, it is somewhat unrealistic to expect a public transport service to provide the comfort and convenience of private transport. It is also possible that respondents perceive public transport as worse than it actually is, with inaccurate perceptions of travel time for example, which could be resolved through the distribution of timetable information and trip planning advice (Shannon *et al.,* 2006). However, one respondent felt in order to increase use of public transport, it would be necessary to change public attitudes:

"People think that only poor people use the buses and they don't want to sit next to wierdos. I think social norms would have to be changed so it was classed as normal to use the bus because everyone else was using it (43)*"*.

According to Anable (2005), even small changes to the numbers using public transport could aid a change in beliefs, attitudes and intentions. However, according to the Theory of Planned Behaviour, control beliefs greatly determine whether a certain behaviour would be performed. Factors that facilitate behaviour, such as flexible working hours, or restrict behaviour, such as time constraints, form an individuals Perceived Behavioural Control (PCB) (Ajzen, 1991). Thus, personal responsibilities such as collecting children from school could render the use of public transport to commute to work beyond an individuals PCB, regardless of the social norm regarding public transport use. Hence, the behaviour would not be performed. Anable (2005) identified differences between car owning segments of society and describes such car users as 'malcontented motorists', who feel increasingly unhappy and frustrated with their car use but perceive a large number of constraints to the use of public transport. It appears highly likely that those with high perceived car dependency would require persuasion with alternative information strategies that targeted such behaviour and offered practical carbon reduction measures. Given that time is a big issue for commuting, measures would be required to improve journey times of public transport in addition to trip planning information (Shannon *et al.,* 2006). However, it is also possible that this group of car users would resort to telecommuting or buying either a more efficient vehicle or a clean fuelled vehicle in order to maintain current levels of car use.

Several respondents were doubtful that public transport would actually improve as a result of the policies being introduced. There was a lack of trust regarding the use of revenue as intended with the removal of funding for the Leeds Supertram being used as an example of the governments' attitude towards improving public transport:

"I'm not convinced that the revenue would actually be used to improve public transport, it'd probably get swallowed up by something else (44)*"* and *"Look what happened with the Supertram, they even started building the tracks and spent quite a bit of money on it and then decided it was too expensive after all* (55)*".*

Whilst the Supertram comments were specific to Leeds, such attitudes regarding the lack of trust in governments' use of revenues were also revealed in a study by Dresner *et al* (2006), where respondents were sceptical about the use of fuel tax revenue to improve public transport. It is perhaps not unreasonable for the public to question the proposed use of revenue in such a targeted way, given the historic use of taxation in the UK to raise revenue for general and often undisclosed purposes (Dresner *et al.,* 2006). However, such attitudes could be quickly changed when the improvements became visible. Conversely, one respondent did not want any revenue to be used for improving public transport services:

"I wouldn't support the use of revenue to improve public transport, it's a private business. Why should our taxes be used to expand a profit making business? If it was given back to government ownership then fair enough, I'd have no problem with that (44)*".*

Many respondents felt that they would not need to make any changes to their travel behaviour and would instead absorb the increased costs:

"I'd just pay that, I wouldn't really notice to be honest and I'd just cut down spending on other things if the prices went up anymore (23)*"* and *"I'd just carry on as normal and hope that I'd get the permits I wanted* (15)*"* and *"I wouldn't care about the cost, I'd pay it if it meant I didn't have to change* (11)*"* and *"I wouldn't like it but yeh I'd just pay it* (7)*"* and *"I don't want to hear about climate change, I just want to get on with my life to be honest* (16)*".*

Such motorists were described by Anable (2005) as 'complacent car addicts' who do not feel moral imperative or other incentive to alter their car use with low potential to switch car journeys to public transport. The provision of education regarding the negative aspects of car use and the positive aspects of public transport use are proposed as the most effective policy options (Anable, 2005) (it should be noted that the potential policy options proposed by Anable did not consider personal carbon trading). However, the effectiveness of such policies should be considered. For example, Stradling *et al* (2000) discovered that information campaigns were considered as push measures, with motorists reacting negatively and feeling they were being labeled as polluters. It is possible that people do not relate general problems, such as climate change, to their own car use (Steg, 2005), hence, the delivery and content of such information would require careful consideration.

5.3 Changes to travel behaviour

In total, 12 respondents stated they would make changes to their travel behaviour only in response to the TCP scheme, 3 respondents stated they would make changes to their travel behaviour only in response to the FPI and 8 respondents stated they would make changes to their travel behaviour in response to both policies. Table 5.2 lists the type and frequency of behavioural response recorded using the low carbon software with number of responses in each time period for both the TCP scheme and the FPI. The behaviours shown were suggested by respondents in reply to an open question (see chapter 3, section 3.5.2).

Table 5.2: Behavioural response with number of responses for the TCP scheme and FPI in 2010, 2020 and 2030

Response	2010		2020		2030	
	TCP	FPI	TCP	FPI	TCP	FPI
Train to work 5 days per week					1	1
Train to work 3 days per week	4		5	1	5	1
Train to work 2 days per week						2
Train to work 1 day per week	1		1	2	1	2
Work locally and walk to work	1		1		1	
Cycle to work	1	1	1	1	1	1
Stop giving lifts to partner						1
Bus to work 5 days/week						1
Bus to work 3 days/week			2		2	1
Bus to work 1 day/week						1
Use bus/train on long distance leisure trips			1		1	1
Buy fuel cell car					1	
Buy most fuel efficient car available	1		1		1	
Car share to work 2 days/week			1		1	
Work at home 1 day per week			1		1	
Walk for short leisure trips	2	1	2	1	2	1
Number of responses	**10**	**2**	**16**	**5**	**18**	**13**

As explained in chapter 3 (see section 3.5.2), when changes were suggested by respondents the journeys were adjusted accordingly in the low carbon software which then displayed the recalculated carbon consumption and estimated monetary cost. For the TCP scheme, respondents were also able to see the impact of any changes in relation to their free carbon permit allocation.

5.3.1 Journey to work

The commute to work appeared to be the most flexible journey for most, in terms of making changes. Where changes were made, train was a much more popular mode than bus because of the perceived faster journey times and increased comfort. Leisure journeys were much less flexible than work trips, with many respondents feeling that car use was their only option for many of their leisure trips due to the level of trip combining involved and journey distance. These results are in contrast to other studies which report leisure trips to be more changeable than commute trips (Jakobsson *et al.,* 2002; Ubbels and Verhoef, 2006). For the TCP scheme, in the short term, train operators would be under more pressure to increase capacity than bus operators. There would be less pressure in response to the FPI policy, in terms of increasing capacity and reducing emissions given that the greatest demand occurred in the long term.

It is evident from table 5.2 that respondents were much more willing to alter their commute to and from work rather than altering other trips. For example, in response to the TCP scheme in 2030, 11 respondents would alter commute trips and only 3 people would alter their leisure trips. Similarly, 10 people would alter commute trips in response to the FPI in 2030, with only 2 people willing to alter leisure trips in the same period. This is logical given that commute trips are likely to be the most frequent trips made and generally have the most fixed route.

Train was preferred to bus, being viewed as a faster, more direct and attractive mode, whereas bus was considered much less reliable given the possibility of being delayed in congested traffic:

"*I'd use the train because at least that won't get held up in traffic like the buses do* (39)" and "*Buses are always late and there's no way of knowing* *when it's going to show up, whereas trains are generally much more reliable and you get told if it's late* (47)".

It is possible that such attitudes could be influenced by the improvement of journey time reliability (for example, by installing bus lanes) and the provision of accurate timetable information. For example in Leeds, Metro have recently implemented a wide scale availability of real time bus information which informs potential travellers waiting at the bus stop the number and arrival time of the next 4 buses.

In addition to those respondents who made changes where feasible, several respondents stated they would like to change their journey to work but perceived difficulties:

"*I'd use the bus but I'd have to get one into town and then one up to the campus, which is ridiculous because I only live three miles away* (19)" and "*It's not possible for me to use the bus to work, there's only one an hour where I live* (56)".

Such responses suggest that PBC was an important determinant of behaviour, given that restraints were perceived regarding the use of public transport to commute to work. Amongst a survey of employees at 2 UK companies, Kingham *et al* (2001) identified a strong willingness to reduce car use for the journey to work only where the conditions were right, for example, where public transport was available within a reasonable journey time.

5.3.2 Leisure journeys

Leisure journeys were considered by the majority of respondents to be much less flexible in terms of switching mode, being more time restrained, and not very feasible to use public transport due to the high level of trip combining involved, for example:

"I couldn't do most of my leisure trips by public transport, for example, if I did that one (pointed to a long-distance leisure trip displayed on the screen), it'd take about 3 times as long and I'd have to get about three different trains. It just wouldn't be worth doing (56)*".*

These results are in contrast to other studies (for example: Ubbels and Verhoef, 2006; Loukopoulos *et al.,* 2006) which have discovered a greater willingness to change leisure and shopping trips with commute trips being perceived as the most difficult to change given the route and time constraints. Whilst shopping trips are reportedly more elastic than commute trips (Ubbels and Verhoef, 2006) and thus easier to change (Jakobsson *et al.,* 2002), many respondents were visiting decentralised shopping outlets (including the White Rose centre, and supermarkets on the outskirts of Leeds), which suggests a problem with accessibility. Many respondents were shopping during the evening and would not want to use public transport largely as a result of perceived lack of availability and personal safety concerns. Several respondents felt that such shopping and leisure areas were only accessible by car and could therefore not use public transport. Stradling *et al* (2000, p.214) discovered similar findings amongst focus groups with the general public where it was largely agreed that many facilities can only be accessed via car: "the whole country is geared up for car use". Thus, many barriers to change or control beliefs could possibly be altered through the implementation of strategic planning laws which would encourage the recentralisation of amenities and prevent the imposition of shopping and/or leisure outlets without the provision of an adequate public transport service.

The willingness to change varied amongst respondents, some were happy to make changes if the policies were necessary and they were helping to reduce the impacts of climate change whereas others were more reluctant and made changes because they felt they would have to:

"I'd use the bus so I knew that I had some permits left to do the shopping and for days out (1)*"* and *"I suppose I could get the train to work 2 days a week if I had to, 3 days at a push. It'd take me longer but I'd just have to do it* (2)*"* and *"I'd have to cut down, fuel already costs too much and I cant afford to pay any more* (17)*"* and *"I could just walk for them short trips, I only used the car to save time but I'd just have to plan it a bit more. If it'll help the environment then it's worth it* (8)*".*

5.3.3 Increasing fuel efficiency

By purchasing the most efficient vehicle in the same class as their current vehicle, respondents could reduce their fuel consumption by up to 30% (SMMT, 2005), which could allow current behaviour to continue without making any changes. However, this option was only mentioned by a small number of respondents:

"If I bought a more efficient car I'd get more use from my permit allowance, so I'd do that straight away (20)*".*

Efficient driving practices, such as changing gear between 2,000 and 2,500 rpm, keeping windows closed, avoiding excessive braking and idling and maintaining optimum type pressure, could save as much as 25% of fuel consumption (Potter *et al.,* 2001; Kroon, 2006; Anable and Bristow, 2007). However, this method of fuel reduction, which would not require a reduction in car use, was not mentioned during the interviews. However, people need to plan their travel (Jakobsson *et al.,* 2002), hence it is highly likely that, given more time to plan their response, many respondents would opt for such fuel saving measures that do not require a reduction in car use. In addition, the awareness of efficient driving practices could possibly be influenced through an information campaign which would provide options for reducing carbon consumption, including driving style. For example, the UK Department for Transport currently have a series of adverts on billboards around the country which provide information on efficient driving practices, such as maintaining the correct tyre pressure and avoiding excessive acceleration and braking.

Many respondents stated that, whilst the scheme would not prompt them to change their current vehicle, when they did need to change their vehicle fuel efficiency would be a very important determinant:

"When I changed my car I'd look really carefully at the efficiency and buy one based on that (8)*".*

Again, it is highly possible that given a supply of information and adequate time to plan, the uptake of more efficient cars (which could allow current car use to continue), could actually be much greater than suggested above.

5.3.4 Walking and cycling

Cycling was not a popular option in response to either policy. It was largely viewed as an unattractive mode due to the perceived safety implications, travel speed and the vulnerability to unpleasant weather conditions. In addition it was viewed as impractical for work trips given the lack of shower facilities available:

"I'd like to cycle because I only live three miles away but because there's nowhere to get a shower, I'd have to ride in my suit and that's just not practical. And there's nowhere to leave my bike on campus (41)*"* and *"I like cycling but not when it's wet and cold* (44)*"* and *"There's too much traffic on the roads, it's not safe for bikes* (48)*".*

It therefore appears that large scale cycling strategies would have to be deployed in conjunction with the introduction of the policies, including the provision of cycle facilities (safe lock up areas and shower facilities at places of employment) and extensive cycle lanes. However, the comments given by respondents could have been excuses not to cycle rather than genuine reasons. Thus, there is no guarantee that the provision of such facilities would significantly increase levels of cycling. For example, Shannon *et al* (2006) found amongst a survey of university employees and students that the travel time and distance from home to work were the main barriers for cycling to work. Jensen (1999) discovered amongst a survey of the general public that cyclists lived within a short distance of their workplace. In addition, amongst a survey of employees at two UK companies, Kingham *et al* (2001) found that cycling levels would increase as traffic levels declined, and that more than 25% of the sample from one company and 15% of the sample from the second company would cycle regularly all year if they lived within cycling distance of work. Hence, the distance from home to work could be a more important determinant of cycling than the provision of cycling facilities. For example, Shannon *et al* (2006) discovered that the introduction of cycle lanes, showers, secure lock ups and a cycle repair shop on campus were not likely to change behaviour amongst a sample of university students and employees. In addition, amongst a survey of employees at two UK companies, Kingham *et al* (2001) found that less than 10% of the sample would cycle to work if cycling infrastructure was improved.

Other studies reported by Kingham *et al* (2001) found that cycling would improve by only 2% amongst a survey of university employees and 13% amongst a sample of employees at a large UK company if cycle lanes were improved. However, in contrast, another study reported by Kingham *et al* (2001) amongst staff from Boots Plc concluded that 23% of the sample would cycle to work if improvements to cycling infrastructure were made. The effectiveness of such measures would therefore require careful consideration prior to implementation given the level of investment and disruption required to extend existing cycle paths and implement new cycle pathways in addition to the facilities at places of employment. It is also possible that changing existing social norms regarding cycling would play an important role in increasing cycling activity.

5.4 Impact of behavioural response on kilometres travelled and carbon consumption

The behavioural changes outlined in table 5.2 are reflected in table 5.3, which displays total kilometres travelled per mode for both the TCP scheme and the FPI.

Table 5.3: Total distance (kilometres) traveled for the whole sample per mode per week (base) with % change in 2010, 2020 and 2030 for the TCP scheme and FPI.

Mode	Base	2010		2020		2030	
		TCP	FPI	TCP	FPI	TCP	FPI
Car	13921	-9.5	-0.6	-17.4	-4.4	-29.0	-11.0
Bus	1719	0.0	0.0	+13.5	+5.0	+13.5	+12.0
Train	4814	+17.4	0.0	+33.1	+8.2	+38.0	+23.5
Taxi	59	0.0	0.0	0.0	0.0	0.0	0.0
Motorcycle	694	0.0	0.0	0.0	0.0	0.0	0.0
Cycle	241	+28.6	+20.3	+33.6	+20.3	+51.0	+20.3
Walk	332	+8.5	+1.6	+11.2	+2.2	+16.0	+4.0
Total	21780	-1.8	-0.1	-2.4	-0.3	-8.4	-0.4

A paired samples t-test was used to explore whether the differences in kilometres travelled between the base and 2030 for each policy were statistically significant, i.e. whether or not the difference occurred by chance. The t-test revealed significant differences for the TCP scheme ($p<.02$) and for the FPI ($p<.025$). In comparison to the UK national average, respondents were traveling more by car, bus, rail, motorcycle and cycle and less by taxi and walking (see chapter 3, table 3.3). However, by 2030 in relation to the TCP scheme, car kilometres were below the UK national average with walking increased to above the national average. Conversely, for the FPI car kilometres remained above UK average and walking kilometres remained below the UK average. The ratio of car kilometres to cycle kilometres declined in relation to the TCP scheme, going from 57 car kilometres per cycle kilometre in the base to 27 car kilometres per cycle kilometre in 2030, therefore reducing the risk of accidents and possibly encouraging greater uptake of cycling. For example, as reported by Kingham *et al* (2001), willingness to cycle increased as traffic levels declined.

Table 5.4 displays carbon consumed by mode in each policy and time period, reflecting the behavioural changes shown in table 5.2 and changes in kilometres travelled shown in table 5.3.

Table 5.4: Total carbon consumption from the whole sample (kilograms) per mode per week (base) with % change in 2010, 2020 and 2030 for the TCP scheme and FPI.

Mode	Base	2010		2020		2030	
		TCP	FPI	TCP	FPI	TCP	FPI
Car	512	-11.3	-0.4	-35.4	-5.9	-38.0	-21.3
Bus	33	0.0	0.0	+32.0	+12.1	+33.0	+24.2
Train	82	+10.0	0.0	+22.0	+4.9	+23.0	+20.7
Taxi	3	0.0	0.0	0.0	0.0	0.0	0.0
Motorcycle	17	0.0	0.0	0.0	0.0	0.0	0.0
Total	647	-7.7	-0.3	-23.8	-3.4	-25.7	-13.1

The total carbon consumed per person during the base and 2030 was significantly different for both the TCP scheme ($p<.02$) and FPI ($p<.025$). The total change in carbon consumption from all modes shows that the increase in public transport offset some of the reductions from car use, for example, in 2030, the TCP achieved a 38% reduction in car carbon but the overall reduction from all modes was 25.7%. This supports the case to reduce emissions from public transport in addition to personal transport modes, as suggested in chapter 3 (see section 3.1).

The reduction in carbon consumed by car use is greater than the corresponding reduction in kilometres traveled by car (see table 5.3). This reflects the switch by one respondent to a smaller car that consumed less fuel, and by another to a fuel cell car in 2030 for the TCP scheme (see table 5.2). Hence, carbon consumption and demand for permits and fuel were reduced without having to reduce vehicle kilometres traveled. For the FPI, the greatest change in carbon consumption was achieved in 2030. Hence, the largest reduction in car carbon from base consumption and the greatest increase in carbon consumed by public transport were achieved in the long term. However, the elasticities applied assume a greater response in the long term (Graham and Glaister, 2000), although it is possible that greater reductions would be achieved before 2030 if supportive measures were made available, such as increased public transport quality and availability, cycle facilities, and local shops. In response to the TCP scheme, the greatest reductions in carbon occurred in 2020, with a further change in 2030 but at a much smaller level. Thus, the capacity and/or willingness to change was almost exhausted in 2020. However, long term supportive measures, such as clean-fuel vehicles at reduced costs and improved public transport, should have been implemented by this point therefore providing additional opportunities to reduce carbon consumption. In addition, the increasing permit price could play a crucial role, thus providing 2 strong signals (cap and permit price increase) in the long term.

5.5 Policy effectiveness

Table 5.5 displays the carbon emissions targets implied by the scheme design values (see appendices 1 and 2) and the actual carbon emissions reductions achieved amongst the sample for both policies in all time periods (derived from table 5.4).

Table 5.5: Carbon emissions reduction targets (percentage change from current) and actual reduction for the TCP scheme and FPI in 2010, 2020 and 2030.

Year	TCP scheme carbon reduction %		FPI carbon reduction %	
	Aim	Actual	Aim	Actual
2010	8.0	11.3	1.7	0.4
2020	21.4	35.4	10.6	5.9
2030	34.8	38.3	25.3	21.3

The emissions targets to 2030 were a 34.8% reduction for the TCP scheme, reflecting the linear reduction in carbon each year, and for the fuel price increases 25.3% reflecting the assumed lower price elasticity in the early years. Despite smaller price increases in each time period (see table 5.1), the TCP scheme over achieved the emissions target in each period whilst, conversely, the FPI underachieved the emissions target in each period. Hence, the TCP scheme was more effective than the FPI at achieving change amongst a group of above average carbon consumers. To give an indication of the difference in effectiveness levels, the carbon reduction targets for the TCP scheme in 2010 and the FPI in 2020 were very similar yet the TCP scheme over achieved the target by 3.3% whilst the FPI underachieved the carbon reduction target by 4.7%. In addition, the change in carbon consumed by car use can be examined per 1% of carbon reduction aim. For example, up to 2030 the TCP scheme aimed to reduce carbon consumed from car use by 34.8% with an actual reduction of 38.3%, hence for every 1% reduction aim a 1.1% reduction was achieved. For the FPI this is quite different - for every 1% reduction aim for carbon used for car use resulted in a 0.8% reduction. Thus, the TCP scheme achieved an average effectiveness of 110% compared to the FPI which achieved an average effectiveness of 80%. However, the main response to pricing is to pay the increased charge and continue current behaviour (Bonsall *et al.,* 2007; Jakobsson *et al.,* 2002), therefore this appears to be a positive outcome in comparison to other findings.

The effectiveness of each policy can also be compared in terms of kilometers traveled in 2030 per mode for every 1% of the carbon reduction target[9]. Table 5.6 shows the figures derived for the whole sample.

Table 5.6: Change in kilometers traveled per mode per week per 1% of the carbon reduction target

	Car	Bus	Train	Cycle	Walk
TCP scheme	-116.0	6.0	53.0	3.5	1.5
FPI	-61.0	8.1	45.0	1.9	0.5

The TCP scheme caused a threefold increase in walking and almost twice as much cycling as the FPI, therefore indicating larger health benefits as a result of the TCP scheme. As a result, social norms regarding active modes would be likely to change more rapidly and more significantly under a TCP scheme. Train use was also greater for the TCP scheme which also caused almost twice the reduction in car kilometres. Interestingly, the FPI caused a greater increase in bus kilometres than the TCP scheme, which is perhaps a result of those earning below average incomes who would typically use bus rather than train responding to the FPI and not to the TCP scheme.

The difference between the actual and expected emissions reduction from the FPI was smaller in 2030 than any other period, however, the elasticities applied assume greater response in the long term (see chapter 3, section 3.2). The fuel price increase was greatest in this period (61.6% - as shown in table 5.1). Thus, to achieve significant reductions from the FPI it appears that fuel price would have to increase by over 50%:

9 Formula used: difference in kilometres travelled between base and 2030/carbon reduction target in 2030.

"I'd have to make changes if the price got that high, that's more than a 50% increase isn't it, I couldn't pay that much, no I'd definitely start to make changes then (21)*"*.

Conversely, Jakobsson *et al* (2002) investigated the effect of fuel price increases amongst car owning households and found that even substantial economic disincentives (100% fuel price increase) were unlikely to cause any large reductions in car use. In addition, Kingham *et al* (2001) found that only half of employees at two UK companies would change their car use if fuel prices reached £10 per litre. A substantial increase in fuel price would be required to have a significant effect on car use (Dargay, 2004), thus, in comparison to existing empirical data, it appears that the current sample were perhaps more willing to change their behaviour, hence it should be considered that amongst a different sample the effectiveness rates of both policies could be much lower.

The limited availability of carbon permits provided respondents with a strong signal and drive for reducing their carbon consumption with many feeling that change would be inevitable for the majority of carbon consumers should the TCP scheme be introduced. Many respondents did not want to be in a situation where they could not make leisure trips or essential journeys by car due to a lack of available permits and instead would rather reduce their consumption from other trips where alternatives were more easily available, such as commuting to work using the train rather than car. The uncertainty of permit availability therefore appeared to be the main driver for behavioural change:

"I'd want to make sure that I had enough permits for my leisure trips, there're some places were you can't use public transport, or it just takes too long. I'd cut back on the work trips and save the extra ones (14)*"* and *"It's the not knowing whether you'd be able to buy what you wanted, and the price of them, so I might not even be able to afford it anyway. I'd have to stick to my*

free allocation and get what my parents don't use, I wouldn't like to risk having to buy more in case there wasn't any there (19)*".*

People are risk averse and would prefer an option with a known price to an option with an uncertain price (Bonsall *et al.,* 2007). Hence, the TCP scheme could actually benefit, in terms of effectiveness, from risk aversion, i.e., people try to minimise the risk of permit shortages by reducing their permit use.

5.5.1 Fuel demand elasticities: applied and derived from survey results

The fuel price increases displayed in table 5.1 and the carbon reductions displayed in table 5.5 can together be used to derive fuel demand elasticities for the sample. Table 5.7 displays the elasticity applied in each time period for the FPI based on those derived by Graham and Glaister (2000) (as explained in chapter 3 - see section 3.2.1) and the derived point elasticity for each period and policy based on the changes to behaviour recorded by the low carbon software during the survey.

Table 5.7: Fuel demand elasticities – applied and derived from survey results[10].

Year	Elasticity applied FPI	Survey results elasticity: FPI	Survey results elasticity: TCP
2010	-0.25	-0.06	-2.97
2020	-0.40	-0.23	-2.57
2030	-0.41	-0.35	-1.08

For the FPI, in each period the elasticities derived from the survey results were much lower than those applied. Hence, the fuel price elasticities applied gave rather different results in comparison to those based on the response of a sample of above average carbon consumers with a higher than expected

[10] Formula: % reduction achieved/% price increase

willingness to pay. From the derived elasticities shown in table 5.7 it is possible to calculate the price increase that would be necessary to achieve the desired carbon reductions, as shown in table 5.5. For example, in 2010, in order to achieve a carbon reduction of 1.7%, fuel price would need to increase by 28.5% which is much higher than the actual increase applied (6.7%). In 2020, a fuel price increase of 46% would be required whereas an actual increase of 25.6% was applied. In order to achieve the desired reduction in 2030, a fuel price increase of 72% would be required, compared to the applied increase of 61.6%. The smallest difference between the required price increase and the applied price increase occurred in 2030 which largely explains the smallest difference between expected and actual carbon reduction in this period, as shown in table 5.5.

Given that the combined fuel and permit prices were lower in each time period then those used in the FPI, the elasticities derived from the survey results in relation to the TCP scheme are clearly dominated by the quantity effect i.e. the reduction in carbon availability over time. As discussed in section 5.5, a number of respondents felt that they would have to reduce their carbon consumption and would prefer to reduce their non-essential trips to avoid a permit shortage. Hence, the derived elasticity represents risk averse behaviour in response to a declining availability of carbon permits, rather than purely a price effect.

5.6 Exploring the changes to travel behaviour

Given the complexity of travel behaviour and the potential influence of attitudes (Steg, 2005; Anable, 2005), this section aims to further explore the motivators for behavioural change amongst participants. In order to identify differences between respondents who changed their behaviour compared to those who did not change their behaviour, a dummy variable was coded as 0 for non changers and 1 for changers. Table 5.8 shows the average scores for the attitude variables reported in chapter 4 and the average base carbon consumption derived from the low carbon software.

Table 5.8: Changers versus non-changers

Variable	Behavioural change		No behavioural change	
	TCP	FPI	TCP	FPI
Environmental concern	5.7	5.5	5.6	5.8
Problem perception	2.7	3.0	2.6	2.6
Knowledge	4.0	3.7	3.7	3.8
Carbon kg/person/week	17.5	14.9	4.7	7.4

In terms of concern for the environment, for the TCP scheme the no changers had on average a slightly lower score whereas for the FPI, the changers had a lower score than those who did not change their behaviour. Problem perception was higher amongst changers in both policies. Knowledge was higher amongst changers for the TCP scheme and higher amongst non changers for the FPI. Hence, based on the lack of clear and consistent relationships, it appears that concern for the environment, problem perception and knowledge were not strong causative factors of behavioural change.

For both policies, carbon consumption was vastly different between respondents who changed compared to those who did not change. Those who changed for the TCP scheme were consuming more than 3 times as much carbon as the non changers and similarly for the FPI changers were consuming over twice as much carbon as the non changers. The data in table 5.8 supports the results in section 5.2, where it was revealed that for both policies the majority of non changers were below UK average carbon consumers and in relation to the TCP scheme were consuming within or very close to the free carbon permit allocation. Conversely, those who changed were consuming significantly above the free permit allocation. Hence, carbon consumption expectedly has a strong influence on propensity to change.

To further explore relationships with behavioural response, a correlation analysis was conducted using a Spearman's rank correlation (explained in chapter 4). For the FPI, statistically significant relationships were revealed between behavioural response and carbon consumption ($p<.01$), with a positive but not very strong correlation coefficient of 0.368 (a value of 1 indicates a perfect correlation). For the TCP scheme, income ($p<.05$), impacts on lifestyle[11] ($p<.01$) and carbon consumption ($p<.01$) had a positive and statistically significant relationship with behavioural response, with carbon consumption having the strongest correlation coefficient of 0.631. Hence, for the TCP scheme, behavioural response increases as income, impacts on lifestyle and carbon consumption also increase. There is likely to be a level of interdependency between the variables in that carbon consumption increases with income which in turn provides more scope and incentive to reduce consumption as income and thus carbon consumption increase. The level of impacts on lifestyle would also depend on the type and level of behavioural response which increases as carbon consumption and income increase. Interestingly, income was not significant in response to the FPI despite a positive and significant ($p<.01$) relationship between income and base carbon consumption. This is possibly a result of the larger number of respondents making changes in response to the TCP scheme than the FPI (20 people compared to 12 people).

Carbon consumption was clearly an important factor in behavioural response. A Spearman's rank correlation revealed significant and positive relationships between base carbon consumption and age ($p<.05$), and income ($p<.01$), with income having the strongest relationship with carbon consumption (coefficient of .534). Gender had a significant ($p<.05$) but negative relationship with carbon consumption which reveals a higher consumption amongst males compared to females (males were coded as 0 and females were coded as 1 in the dummy variable for gender). Hence, the likelihood of behavioural change

[11]'Impacts on lifestyle' variable measured the scale of impacts on lifestyle resulting from the TCP scheme and FPI – chapter 3 (section 3.5.2) and chapter 6 (section 6.1).

increases as carbon consumption, income, age and distance travelled increase. In addition, males are more likely to change their behaviour although this is expected given that men tend to travel greater distances than women (DfT, 2006b), which was also revealed in the correlation analysis as a negative relationship between gender and distance travelled.

The following section further explores the relationship with behavioural response (presented as carbon consumption in each time period) and income, which was significantly and positively correlated with distance travelled ($p<.05$) and carbon consumption ($p<.01$).

5.6.1 Income

The demand for fuel is heavily dependant on income (Graham and Glaister, 2000). It is therefore logical to assume that behavioural response to a policy that imposes monetary penalties would be largely influenced by the ability to absorb such penalties, and thus that income might be a key indicator of propensity to change. The elasticities used to derive the fuel price increases assume that an individual will maximize their utility when faced with increased expenditure (Dresner and Ekins, 2004). The extent to which monetary aspects are important in the consideration of utility are likely to be influenced by income, with other factors such as instrumental (convenience), affective (enjoyment of driving) or symbolic (status) motives becoming more important as income increases and resultantly make pricing policies less effective (Steg, 2005). Amongst the sample, 27% earned below the UK average gross household income, 38% had an average gross household income and 35% earned above the UK average gross household income (see chapter 3, table 3.3). Table 4.9 provides carbon consumption by mode split by gross annual household income across the whole sample for both policies in each time period. It should be noted that the table is designed to explore the relationship between income and carbon consumption in each time period and policy, rather than provide comparisons between the policies given that the carbon reduction targets differed in each time period (see table 5.5).

Table 5.9: Carbon consumption (kilograms) per person per week (base) with % change from base in 2010, 2020 and 2030 split by travel mode[12] and income group for the TCP scheme and FPI

Year	Mode	Below average income		Average income		Above average income	
		TCP	FPI	TCP	FPI	TCP	FPI
Base	Car	1.8	1.8	9.5	9.5	13.2	13.2
	Bus	1	1	0.4	0.4	0.3	0.3
	Train	1.8	1.8	1.5	1.5	0.9	0.9
2010	Car	0	0	-20	0	-5	-0.4
	Bus	0	0	0	0	0	0
	Train	0	0	+20	0	0	0
2020	Car	0	-11	-35	-6	-40	-6
	Bus	0	+10	+50	0	+133	+33
	Train	0	0	+47	+9	+11	0
2030	Car	0	-11	-38	-23	-43	-21
	Bus	0	+10	+75	+25	+133	+100
	Train	0	0	+47	+33	+11	+22

The data shows a highly positive relationship between carbon consumed by car use and income and a reduction in carbon consumed by bus and train as income increases. However, this is expected given the proportionate increase in car travel and reduction in travel by other modes in relation to income (DfT, 2006b). Despite the TCP scheme having higher carbon reduction targets, the FPI was the only policy to cause changes amongst the below average income group. This group had the least potential to reduce their carbon consumption, given they were substantially below the average carbon consumption (from car

12 Motorcycle and taxi were excluded from the analysis as no changes to these modes occurred in any time period or policy.

use) in the UK. The majority of this group had excess carbon permits, therefore removing the necessity to respond to the TCP scheme. This suggests that the TCP scheme could have fewer equity impacts amongst low income groups in comparison to the FPI which in turn could greatly influence the public acceptability of the policy (Jakobsson *et al.,* 2002; Veigas, 2001).

Given their above average consumption of carbon from car use, the average income group had much more potential to change in comparison to the below average group, although the greatest potential to change was amongst the above average income earners who had the highest carbon consumption from car use. Changes were made by this group in response to each period and policy, with the greatest response to the TCP scheme occurring in the medium term (2020) and the greatest response to the FPI occurring in the long term (2030). As expected, for the FPI the average income earners made greater reductions than the above average income earners who were better equipped to absorb the increased fuel costs to a larger extent. The impact of price would be expected to be low amongst above average income earners (Brand *et al.,* 2006), and although the reduction in car use increased significantly in 2030 it was below the carbon reduction target of 25.3% (see table 5.6). This demonstrates that in order to achieve the desired levels of carbon reduction amongst this group, fuel price would need to be increased by over 50%. This also applies to the average income group who also made much greater changes in response to the FPI in 2030 compared to the other periods.

Conversely for the TCP scheme, the carbon reduction target was overachieved in nearly all time periods by the average and above average income groups, being underachieved only in 2010 by the above average income group. However, whilst this group resisted change in the short term (2010), they achieved greater reductions in the medium and long term than the average income earners. Thus, amongst the highest consumers, it appears that a TCP scheme could be more effective at reducing emissions than fuel price increases. This again demonstrates the impact of the limit placed on permit availability, with many respondents feeling like they would have to change their consumption whilst being allowed to largely continue current consumption under the FPI but at a higher price. However, the response may be quite different amongst a nationally representative sample, given the generic nature of the fuel price elasticity applied.

5.7 Long term behavioural response

In order to explore behavioural response beyond 2030, respondents were shown a list of 11 activities and asked how likely they were to do each activity in the long-term in response to both policies. Each activity was rated on a scale ranging from -3 (very unlikely) to +3 (very likely). Table 5.10 shows the number of responses in each category.

Table 5.10: Likelihood (number of responses) of activity uptake in the long term (up to 2050) for the TCP scheme and FPI

Activity	TCP scheme			FPI		
	Unlikely	Unsure	Likely	Unlikely	Unsure	Likely
Car share	16	14	30	19	13	28
Move house closer to	41	7	12	38	8	14
Change job closer to	36	8	16	31	9	20
Telecommute	19	9	32	18	11	31
Shop online/home	20	7	33	22	10	28
Buy alternative fuel	8	8	44	10	11	39
Increase vehicle fuel efficiency	6	6	48	9	7	44
Use public transport	15	10	35	12	14	34
Cycle to replace short car trips	24	11	25	26	12	22
Walk to replace short car trips	5	14	41	9	12	39
Trip combine	-	3	57	-	5	55

Cycling received a similar number of responses in the likely and unlikely categories which indicates a split response. Conversely, other activities such as walking to replace short car trips, using public transport, increasing vehicle efficiency, buying an alternatively fuelled vehicle, telecommuting and car sharing received many more 'likely' ratings then 'unlikely' ratings therefore suggesting that the majority of respondents would do such activities. Moving house to live closer to work and moving job to work closer to home were largely at the 'unlikely' end of the scale therefore suggesting that the majority of respondents would not do such activities.

Where the majority of respondents rated an activity as likely for both policies, there were more responses in relation to the TCP scheme than the FPI. The difference is particularly noticeable in regard to shopping online, buying an alternatively fuelled vehicle and buying a more fuel efficient vehicle. It appears that the TCP scheme would encourage a greater uptake of these activities than the FPI, which was possibly a result of the TCP scheme being largely viewed as a more restrictive policy that would force change, whereas the FPI allowed respondents to continue their current behaviour if they were willing to pay the increased cost. Hence, respondents felt it more necessary to implement carbon saving measures in response to the TCP scheme.

Many respondents recognised the benefit of reducing their fuel consumption whilst maintaining vehicle kilometres through the purchase of a more efficient vehicle. However, several respondents stated they would only purchase a more efficient vehicle when it became necessary to replace their old one, which was envisaged to be in the long term. In addition, many respondents felt that a more efficient vehicle would be smaller in size and would not therefore sufficiently accommodate their needs in terms of transporting family members and luggage. Others thought vehicles such as the hybrid models were too expensive and would only consider purchase should the price be reduced, which was envisaged to occur over time as demand increased as a result of the constraints on carbon emissions. This suggests a much greater demand for increased fuel efficiency in the long term, therefore providing regulators and manufacturer's ample time to achieve and supply such vehicles. Respondents generally had more doubts about purchasing an alternatively fuelled vehicle, such as a fuel cell car, with more respondents being likely to purchase an increased fuel efficiency car. Many respondents answered this question with a caveat. For example:

"I'd get a hydrogen car if the prices came down and if I didn't have to drive too far to refuel (27)*"* and *"I'd get an electric car if you could go further than 30 miles without having to recharge the battery* (8)*".*

Telecommuting was answered in a similar way, with more than half of the sample stating they were likely to work from home. Many respondents stated that they would like to work from home now under the current situation but felt that their employer would not allow it:

"I'd definitely work from home if I could, I'd do it now if my employer would let me. There's no reason why I can't work at home and it'd save me a lot of traveling (39)*"* and *"It needs to be an option offered by employers, as well as flexible hours so we're not all driving in during the rush hour* (47)*".*

This suggests a large potential to reduce carbon emissions resulting from commute trips, which after leisure trips, are the largest generator of passenger miles in the UK (DfT, 2006a). This is a measure that would be attractive to many people as it would reduce the time spent traveling, hence more time spent on leisure activities, and is probably much more favourable than using alternative modes, such as using the bus instead of driving to work. However, there is a possibility that increased leisure time would result in increased travel by car for leisure purposes, therefore offsetting any carbon savings gained from teleworking. Whilst in theory the potential to telecommute amongst this sample was large given the nature of their employment (predominantly office

based with very infrequent off-site visits), it would differ amongst employment types which could be taken into account when targeting employers with telecommute options/facilities.
For both policies, the majority of respondents were unlikely to move house to live closer to work and change their job to live closer to home. Many respondents were happy with their current circumstances and would not be willing to change, for example:

"I live in a nice village, I don't want to move closer to work, it's not a nice area (5)*"* and *"I couldn't get a job close to where I live and I like the job I've got* (7)*"*.

In response to both policies, over half of the sample stated they were likely to use public transport. Interestingly, more respondents were unlikely to use public transport beyond 2030 in response to the TCP scheme than the FPI despite a higher increase in public transport kilometers in response to the TCP scheme than the FPI (see table 5.3). It is possible that respondents were taking into account the changes they had already made up to 2030 in response to the TCP scheme and thus considered the long term changes as additional, hence further changes were unlikely given that car trips had already been changed to public transport where possible. In relation to the FPI, it is possible that respondents were taking into account further fuel price increases which could have encouraged the switch to public transport in the long term.

In response to the TCP scheme, cycling to replace short car trips was considered unlikely and likely by an almost equal number of respondents, whereas the majority rated cycling as an unlikely activity in response to the FPI. Again, this could be a result of respondents feeling that the FPI was not as forceful in terms of changing mode, given the option of paying the increased costs and continuing car use. However, the comments provided during the interviews indicated safety concerns as the most important reason for avoiding cycling:

"I couldn't cycle, it's too dangerous. People drive too fast and they don't see bikes (1)*"* and *"The weather's not good enough to cycle in this country and we don't have any cycle lanes. When I lived in Germany they had cycle lanes everywhere, I used to cycle to work everyday along the river, it was lovely, much better than what I'm doing now* (3)*"*.

It is highly possible that perceptions regarding safety whilst cycling could be altered through the use of targeted information campaigns, thus increasing the propensity to cycle without the need for traffic reduction measures.

Half of the sample would be likely to car share in response to the TCP scheme and just below half would car share in response to the FPI. Many respondents stated they would not like to share their car with a stranger or a colleague:

"I don't like the idea of sharing my car plus it'd be awkward because I sometimes do the shopping on my way home but I wouldn't be able to if I had to drop someone off. I know people that do it and it works for them, and there're these clubs now aren't there but it wouldn't be right for me, I wouldn't like to do it (33)*"*.

Car sharing might appear to be a practical method of reducing carbon emissions that allows car use to continue and thus all of the convenience and comfort associated with car use, however there are also inconveniences associated with this activity such as having to compromise driving conditions (for example, radio on or off, windows open or closed), route choice, journey origin time and sharing a confined space with a stranger for example. Loukopoulos *et al* (2006) revealed that car sharing was the most unpopular car use reduction method for commute and shopping trips, being much more favourable for leisure journeys. However, such trips are likely to be made with family members and/or friends rather than colleagues or strangers as for the commute to work. As mentioned by several respondents there are also issues with reliability and some had negative experiences that could deter them from retrying car sharing:

"It can be a nightmare, I did it once and I got let down so many times and had to drive my own car anyway that it wasn't worth doing. I don't mind sharing my car and I would do it if it worked (11)*".*

Where people have had negative experiences it could be difficult to encourage car sharing. Kingham *et al* (2001) found amongst a sample of British car owners a potential to car share, with 51% of respondents prepared to participate. However, car sharing was considered to be unreliable, with many respondents feeling more inclined to participate if they were guaranteed a free taxi home should their car sharing partner be unavailable. Hence, car sharing could increase significantly but is clearly a measure that would require government investment and employer support, for example through offering incentives such as parking priority.

To indicate the overall likelihood for each activity across the whole sample, table 5.11 shows the averaged scores.

Table 5.11: Average rating for likelihood of behavioural change in the long term for the TCP scheme and FPI (standard deviation in brackets).

Activity	TCP scheme	FPI
Car share	0.43 (2.11)	0.34 (2.16)
Move house closer to work	-1.48 (2.04)	-1.34 (2.11)
Change job closer to home	-1.05 (2.06)	-0.86 (2.23)
Telecommute	0.48 (2.23)	0.36 (2.35)
Shop online/home delivery	0.34 (2.20)	0.12 (2.17)
Buy alternative fuelled vehicle	1.28 (1.78)	1.03 (1.86)
Increase fuel efficiency of vehicle	1.79 (1.59)	1.50 (1.88)
Use public transport	1.00 (2.10)	0.80 (2.20)
Cycle	-0.16 (2.07)	-0.47 (-1.98)
Walk	1.53 (1.72)	1.10 (1.94)
Trip combine	2.34 (0.89)	1.86 (0.98)

The most favourable activity for both policies in the long term would be trip combining. However, many respondents were already combining trips, for example, shopping on the way home from work was popular amongst the sample. There would be potential to combine leisure trips to a larger extent, given they were more fragmented. Loukopoulos *et al* (2006) found that in response to car use reduction goals, trip combining was the most popular adaptation behaviour for shopping trips, the second most popular option for commute trips and the third most popular option for leisure trips. It therefore appears that people prefer to make smaller changes where possible. Due to the large standard variations, trip combining is the only activity where the sign of the average score is certain for both policies in relation to the same activity. However, table 5.10 shows which category of likelihood had the most responses. For example, in table 5.11, the standard deviation on the average likelihood for moving house closer to work indicates this activity could be likely or unlikely, whereas table 5.10 shows that the majority of respondents (68% for the TCP scheme and 63% for the FPI) considered this activity to be unlikely for both policies.

Respondents were asked if they would find it difficult to adapt and whether they would require help to adapt to the introduction of the FPI or TCP scheme. Table 5.12 displays the number of response to each question.

Table 5.12: Number of respondents that would have difficulty adapting/needing help to adapt to the TCP scheme and FPI

	TCP scheme	FPI
Difficult to adapt	32 (55%)	24 (41%)
Help to adapt	47 (81%)	34 (59%)

More respondents would find it difficult to adapt and need help adapting to the TCP scheme than the FPI. This was largely a result of the concept of fuel price increases being familiar to respondents, whereas the TCP scheme was a new more complicated scheme that involved greater levels of adaptation and learning. The main difficulties related to the TCP scheme were perceived to be the inconvenience of having to use the permit card and monitor the permit account and the time implications of using public transport:

"I don't think it'd be difficult as such, just more inconvenient really with having to swipe your card every time you bought fuel and then worrying if they'll be any left when you want more petrol (9)*"* and *"You'd have to learn about the permits and carbon and what they're worth but I'm sure it wouldn't take that long to get used to it* (23)*"* and *"If I had to get the train to work that'd be difficult for me because I'd have to arrange for someone to pick my kids up from school* (2)*"* and *"I wouldn't be able to work late if I had to use public transport, there isn't a bus back at that time and I wouldn't feel very safe using it* (27)*".*

The majority of the sample stated that they would need help to adapt to the TCP scheme. The main measures were improvements to public transport in terms of availability, frequency, comfort, reliability and connecting services such as train and bus; essential car user allowance (increased permit allocation for people that have no other transport option), flexible working hours; and incentives to buy smaller cars and cycles. Many respondents also felt that a national information campaign would be essential in order to make everyone aware of the permit scheme and how it works:

"Everyone would need a lot of information about it, how it works and what you can do with your permits. I can imagine some people getting really confused (16)*"* and *"If I've got to use public transport then it'd need a lot of improvement, night services, cleaner buses, routes that connect up so you're not waiting half an hour in between. All the things they already do in other European countries really* (51)*"* and *"The government need to make employers let people work at home, it's ridiculous really, we need flexible working hours so we don't have to do 9 'til 5 everyday* (49)*"* and *"The working week's too long, if I didn't have to work 8 hours a day I could use public transport and still have time to spend with my family* (44)*"* and *"The government should provide incentives to use cleaner cars, like taking the purchase tax off and reducing the road tax* (12)*".*

It appears that many of the perceived difficulties largely result from respondents building their lives around car use, which for example allows them to work in a different city to where they live whilst also having children. The reliance on car use to maintain current lifestyles represents a major problem in society (Jensen, 1999; Lyons *et al.*, 2002) and a particular obstacle in terms of response to the introduction of the FPI and more so in relation to the TCP scheme given the limit placed on carbon availability. It would be very difficult to encourage or enforce lifestyle changes. Kingham *et al* (2001) suggest the introduction of a scheme whereby employers provide incentives for employees to live closer to work i.e. within walking or cycling distance or on a public transport route. However, the incentives would in most cases need to be large and outweigh, for example, the attractiveness of living in a remote village compared to a city. This method also relies on people's willingness to take up such incentives, hence the success rate could be highly unpredictable.

Many respondents felt that the FPI would not require adaptation as they were familiar with fuel price increases and would not alter their behaviour:

"*Well it's no different to what happens now, I wouldn't need to adapt* (22)" and "*We expect fuel price to go up and carry on going up and we just put up with it* (55)".

This again demonstrates the inadequacy of the FPI as a carbon reduction measure in terms of allowing current behavior and attitudes to continue. The measures to aid adaptation to the FPI were very similar to those listed for the TCP scheme, such as information regarding fuel efficiency, reduced tax for vehicles that are more efficient, essential car user allowance, public transport improvements, cycle lanes, and flexible working hours with telecommute options. Several respondents felt that it would be helpful to have a form of revenue redistribution in order to help them adapt to the FPI:

"*They'd have to reduce tax on something else wouldn't they, that'd help. Like if they reduced income tax at the same time it wouldn't be as bad then* (58)" and "*Some of the revenue could be used to reduce other taxes, like VAT or income tax* (29)".

The TCP scheme provides a free permit allocation, during the use of which no additional fuel costs would result. The same effect could possibly be replicated in the FPI policy through the redistribution of revenue, or a double dividend approach where the revenue would be used to reduce another tax, such as income tax (Dresner *et al.,* 2006).

5.8 Conclusions and policy implications

More than a third (23 people) of the sample said they would alter their travel behaviour in response to either the TCP scheme or FPI in at least 1 time period. This is similar to other findings (Ubbels and Verhoef, 2003; Stradling *et al.,* 2000). For the TCP scheme, most of the changes occurred in 2010 and 2020 whilst the majority of response to the FPI occurred in 2030. This demonstrates the different levels of response - the introduction of the TCP scheme would result in more urgent change being achieved in the short and medium term, with the potential to change decreasing in the long term whilst the response to the FPI was largely in the long term with reluctance to change in the short term.

The majority of respondents (37) would not make any changes in response to either scheme, however the majority of these were consuming within their free carbon permit allocation during one or more time periods and therefore did not have to change their behaviour in response to the TCP scheme. Many respondents felt unable to reduce their car use in response to either policy, mainly because of family commitments and time issues related to using public transport. Many other respondents did not want to reduce their car use in response to either policy and would instead try to buy the amount of permits they needed and pay the increased fuel costs. Thus, even within a small sample, different groups of car users were identified. Anable (2005) also recognised distinct groups of motorists and suggested that each group be targeted based on the characteristics displayed amongst that group. It therefore appears that it would be necessary to implement targeted information campaigns with specific motivations for change and practical carbon reducing solutions.

Whilst it is possible that some respondents were making excuses rather than valid reasons for non response, in many cases it was evident that low levels of Perceived Behavioural Control (PBC) inhibited a response. In addition, lifestyle choices were restrictive in terms of limiting the options available, for example 9 respondents who made no changes were living in a different city to where they worked. In addition, family responsibilities restricted journey times. Whilst the car is considered by many to provide freedom, for example providing the option of commuting between cities whilst also maintaining family commitments, this in turn leads to car dependency in order to sustain such lifestyle choices, thus creating a 'freedom paradox' (Jensen, 1999). Providing the option of teleworking could provide a practical solution for many, however this would require employee cooperation or government legislation and could in turn result in an increase in leisure journeys, which is perhaps more of a problem in relation to the FPI where there are no limits on carbon availability. Hence, there are many potential problems to consider in relation to encouraging car use reduction amongst those with low PBC.

Perhaps the most intriguing result in terms of policy implications is related to the ability to reduce carbon emissions to the desired level. Whilst the TCP scheme overachieved the carbon reduction target in each time period, conversely the FPI failed to achieve any of the carbon reduction targets. Comparatively, the TCP scheme attained an average effectiveness rate of 110%, whilst the FPI was only 80% effective. Hence, amongst a sample of above average carbon consumers with high potential to reduce their carbon consumption, there was a much greater response to a limit placed on carbon availability than increasing fuel prices. It appeared that the TCP scheme benefited from risk averse behaviour in that many respondents would reduce their carbon consumption in order to avoid uncertainty regarding permit availability.

The response to the fuel price was more inelastic then expected. However, it is possible that amongst a representative sample the elasticity applied would be more effective, as indicated during the analysis on carbon consumption split by income where those consuming substantially below the UK average and with below average incomes were the only group to achieve any of the carbon reduction targets related to the FPI. Although this itself indicates problems regarding inequities, which could in turn seriously hinder the policy in terms of low acceptability levels. Thus, in addition to effectiveness issues, there are potential problems regarding equity impacts, which leads to the question: how can the FPI be made effective and equitable? The obvious solution to equity concerns is a form of revenue redistribution to minimise the inequities, for example by reducing income tax levels. However, without a limit on availability, willingness to pay would still determine effectiveness despite further price increases. Hence, the FPI could be more suited to raising revenue that could be used to aid the provision of renewable energy, efficient technology and other carbon reduction measures. Hence, instead of investigating which policy would be more effective at directly reducing carbon emissions, the options would become either a TCP scheme that effectively reduces carbon emissions directly from the source in addition to raising sufficient revenues for supportive measures, or a FPI used to raise revenue in order to indirectly reduce carbon emissions.

However, there are limitations regarding the 'technical fix' solutions in terms of availability and supply issues (Potter *et al.,* 2001), which implies that ultimately it might be necessary to reduce the demand for carbon rather than replacing carbon with clean fuels, which then makes the TCP scheme more appropriate. However, it would be useful to conduct a full cost benefit analysis of both options which would include any such limitations.

The survey results strongly indicate issues regarding the effectiveness of the FPI. In their draft Climate Change Bill, the UK government have set out legally binding carbon reduction targets amounting to a reduction of 60% by 2050 (DEFRA, 2007). Given the imperative nature of reducing the impacts of climate change and thus securing the carbon reduction targets, the TCP scheme would, based on the survey results, be a much more effective policy than the FPI.

Chapter 6

Impacts on lifestyle, fairness and perceived effectiveness of the Tradable Carbon Permit scheme and fuel price increases

This chapter analyses the quantitative and qualitative data collected after respondents had considered their behavioural response to each policy (reported in chapter 5). Section 6.1 reports the level and strength of impacts on lifestyle followed by the costs and benefits in section 6.2. Fairness is explored in section 6.3 with perceived effectiveness reported in section 6.4. The affect of each policy on a range of measures is also explored. Section 6.5 details the range of alternative measures that respondents considered to be more effective than the TCP scheme and the FPI. Section 6.6 contains the chapter conclusions. Respondents were asked to provide responses in consideration of the whole timescale of both policies. The average ratings reported are from the full sample unless otherwise stated. To show the statistical dispersion of ratings around the average, standard deviation is provided (in brackets) which is measured in the same units as the average. Quotations taken directly from the interview discussion are included to exemplify varying attitudes across the sample.

6.1 Impacts on lifestyle

Respondents were asked if there would be any impacts on their lifestyles if the policies were introduced, and if the impacts would be considered to be positive or negative. Responses to the first question were given on a 7-point scale ranging from 0 (no impacts) to 6 (very many impacts), and to the second question on a 7-point scale ranging from -3 (very negative) to 3 (very positive). The average ratings from the whole sample for both questions are displayed in table 6.1.

Table 6.1 Impacts on lifestyle

	TCP scheme	FPI
Level of impacts	2.48 (1.55)	2.29 (1.61)
Strength of impact	0.42 (1.61)	- 0.21 (1.50)

Given the greater level of behavioural response generated by the TCP scheme (see chapter 5), it might be expected that a greater level of impacts would result in comparison to the FPI, however, the results suggest that the extent of the perceived impacts on lifestyle were similar for both policies. Whilst, on average, the impacts resulting from the TCP scheme were perceived to be slightly positive, slightly negative impacts were perceived to result from the FPI.

The difference between the impacts ratings of the two policies were tested for significance using a Wilcoxon signed ranks test, which is a non-parametric alternative to a paired samples t-test used in the previous chapter where the data was normally distributed. Like the paired samples t-test, the Wilcoxon signed ranks test can be used to measure differences amongst the same sample. A significant difference indicates that the difference did not occur by chance, hence other factors are responsible for the difference. The test requires data to be measured at an interval level and does not make assumptions about the distribution. The test has been used here to measure differences between ratings given for the TCP scheme and the FPI. The Wilcoxon test revealed no significant difference between the level of impacts ratings, whilst the difference between the strength of impacts ratings was significant ($p<.005$).

The standard deviation values indicate a wide dispersion of ratings away from the average, however, this is most likely to be a limitation of the sample size. Therefore, to provide more detail the frequencies of response are presented in figures 6.1 and 6.2.

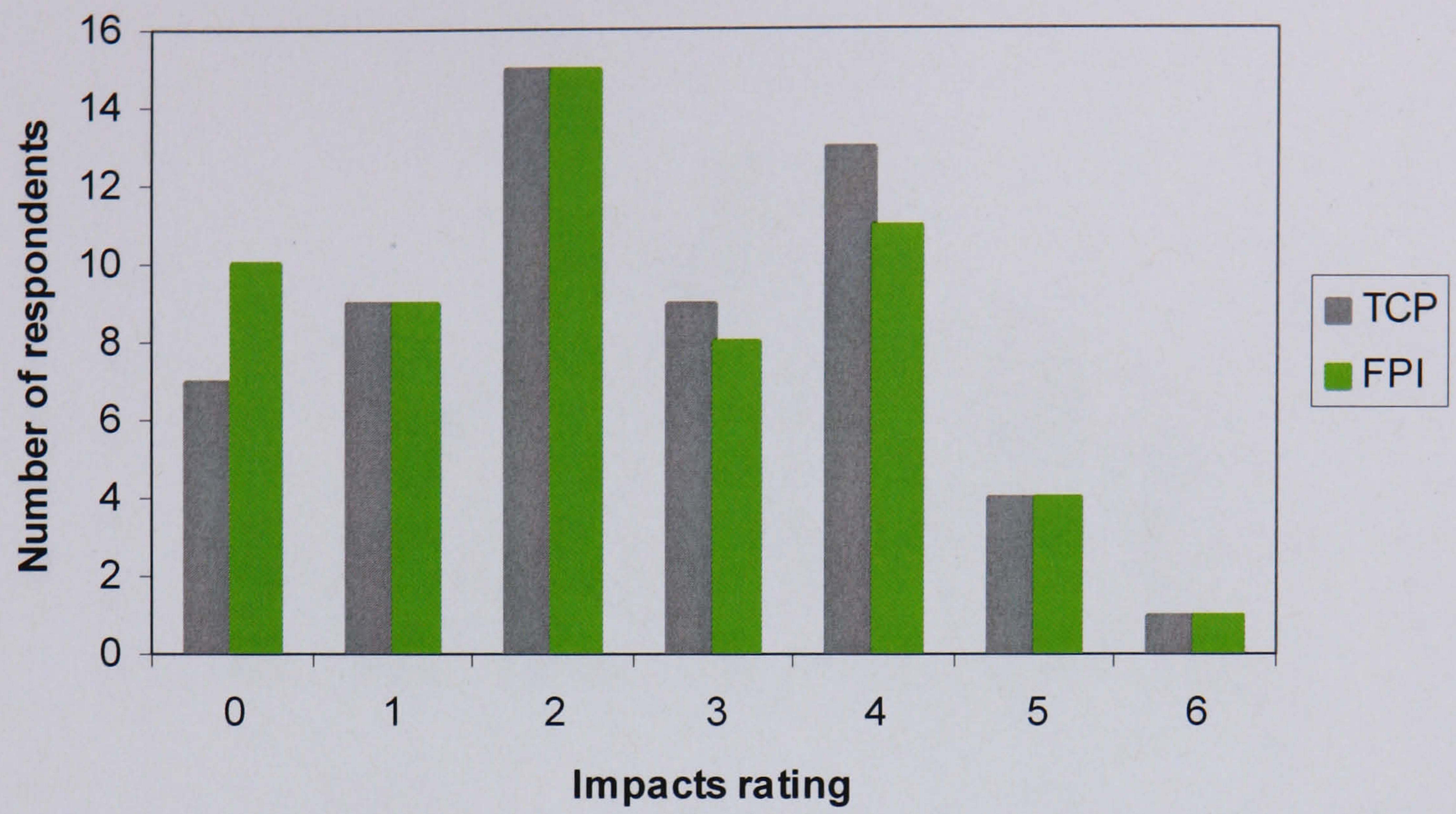

Figure 6.1: Level of impacts on lifestyle

Figure 6.1 displays the similarity in responses with the majority of respondents identifying a small amount of impacts on their lifestyles as a result of both policies.

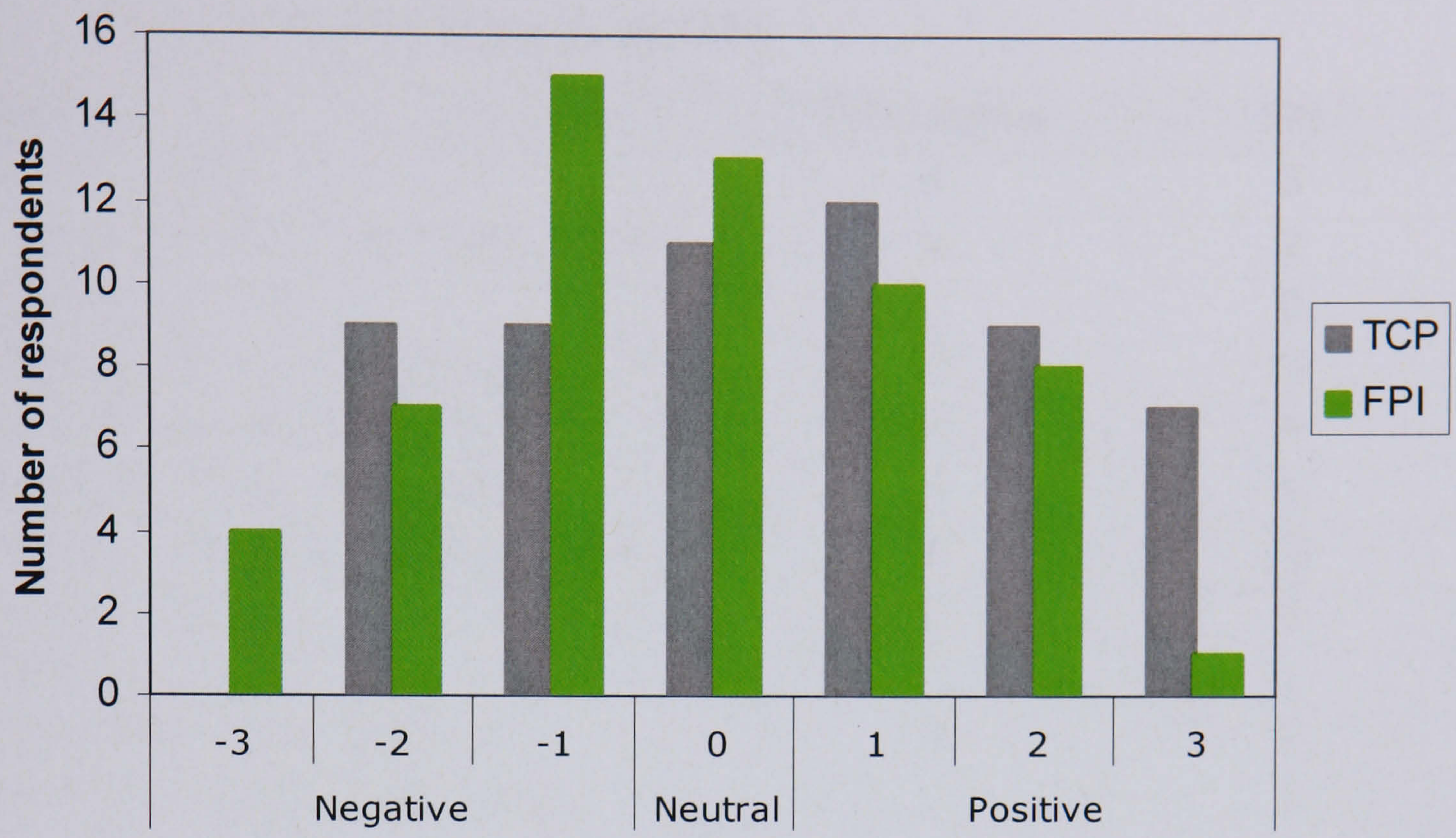

Figure 6.2: Strength of impacts on lifestyle

Figure 6.2 displays the variation in responses across the sample. Whilst the majority of respondents rated the impacts on their lifestyles arising from the TCP scheme as positive, the majority of respondents regarded the impacts arising from the FPI as slightly negative.

Table 6.2 shows the frequency of the types of impacts stated in response to open questions following the categorical rating of impacts on lifestyle (see appendix 4 for interview questionnaire).

Table 6.2: Type of impacts on lifestyle (with number of respondents) as a result of the TCP scheme and FPI

Impact	TCP scheme	FPI
Buying new car	6	5
Having to think about 'being green'	6	2
Holiday in the UK	1	0
Thinking about necessity of car use	23	18
Using public transport more	13	9
Spending less in other areas	3	5
More money spent on fuel/car use	4	22
Less leisure trips	6	9
More exercise	5	1
Try to work closer to home	3	1
Use other modes (cycle, walk)	7	3

A number of respondents felt that neither policy would have an impact on their lifestyle as they had very low levels of carbon consumption and/or car use at the time of interview.

The most commonly reported impact resulting from the TCP scheme was thinking about the necessity of car use, the use of alternative modes and reducing fuel consumption through efficient driving and trip combining. In addition, this included monitoring permit use and calculating the permit cost of car journeys. Thinking about car use was also frequently noted in relation to the FPI:

"I suppose it's having to think about what's currently taken for granted (48)*".*

These impacts were largely considered to be positive as they would make respondents feel like they were contributing to reducing environmental pollution whilst also using modes that they would not have been inclined to use otherwise. In addition, benefits were perceived, such as an improvement in health and fitness levels from an increased use of cycling and walking:

"I'd have to talk to my husband about our permit allocation and ways to reduce our car use so I suppose they'd be communication benefits as well (13)*"* and *"I'd feel good about it, knowing that I was doing my bit and staying in my allowance* (29)*"* and *"This'd make me think more about the environment than the money aspect* (05)*".*

Using public transport was an impact reported by a number of respondents. However, for some respondents this was regarded as a positive impact that would possibly reduce their journey time to work and reduce stress levels by not driving and having time to read a book. Other respondents noted the negative aspects including having to follow a timetable rather than having the choice of journey time as when using a car. Fewer respondents stated the use of public transport as an impact of the FPI in comparison to the TCP scheme, however this is likely to be explained by the greater amount of public transport kilometres stimulated by the TCP scheme (see chapter 5).

Reducing the frequency and/or length of leisure journeys and spending time to plan trips using public transport was one of the main negative impacts on lifestyle arising from the TCP scheme. However, more respondents noted this impact in relation to the FPI:

"I wouldn't be able to do as many leisure trips, like going to see my friends. I wouldn't like that (52)*" and "I'd have to do less social trips, and they wouldn't be able to visit me as often* (24)*".*

Other negative impacts included having holidays in the UK due to an increased expenditure on fuel and purchasing a new vehicle:

"We'd have to have our holidays in this country if we were spending more money on fuel and the coupon things. If we changed our car we'd definitely be having our holiday here (19)*".*

Whilst the impacts ratings shown in table 6.1 appear similar for both policies, from the interview discussions it was clear that respondents' perceptions of the policies were very different. In general, it was considered that both policies would result in increased costs and having to think about the necessity of car use, however the TCP scheme provided options to avoid excessive costs (through the free permit allocation) whilst for the FPI respondents felt that they would have to either spend more money on fuel or reduce their consumption without the purpose of the policy being obvious on a day to day basis, whereas the purpose of the TCP scheme appeared to be more memorable whilst also providing increased flexibility and options:

"I think because you've got to use the carbon permits all the time it'd really make you think about what you were doing and the impact on the environment, whereas with the fuel prices you'd be told what the purpose was at the beginning but it'd be less obvious in an every day way and people might easily forget and just get mad about paying more for their fuel (31)*".*

The permit allocation and limit on carbon availability thus provided a strong motivation for change (as also discussed in chapter 5), and in turn was thought to stimulate 'green thinking' with many people adapting other aspects of their lifestyles and energy use as a result of increased concern for the environment and particularly climate change. Conversely, the FPI did not stimulate the same positive thought process and actions as the TCP scheme:

"The environmental reasons aren't as strong for this one (FPI) so it makes it seem less important and more of a tax than a way to reduce pollution (41)*".*

However, it is possible that labeling the FPI as a carbon tax or levy could help to make the purpose more obvious and memorable.

Many respondents believed that the majority of people would not make any changes in response to the FPI and that they were thus amongst a minority that had to make changes, which they viewed to be negative:

"*This just feels like a tax increase that most people can ignore* (28)" and "*I'd have to change and the impacts would be pretty much the same as the other one (TCP scheme) but it'd annoy me to know that the rich people could still drive their cars as much as they liked. I don't feel like I'd really benefit from changing for this one (FPI)* (44)".

Thus, the difference between the impacts ratings appeared to largely revolve around fairness issues with respondents feeling that the impacts would be positive if other people were also having to make changes. In relation to the TCP scheme:

"*I'd still have to change but it seems like it'd be worth it because other people were making changes as well* (07)" and "*I'd know that everyone else had to change so it wouldn't just be me having to get the bus to work* (15)".

Given that the majority of impacts were expectedly related to changes to travel behaviour, the average rating of impacts and strength of impacts were derived for those respondents who changed their travel behaviour and those respondents who made no changes to their travel behaviour. Table 6.3 shows the results.

Table 6.3: Impacts on lifestyle – changers versus non changers

Attitude	Behavioural change		No behavioural change	
	TCP	FPI	TCP	FPI
Level of impacts	3.39 (1.34)	3.09 (1.22)	2.08 (1.47)	2.11 (1.65)
Strength of impacts	0.28 (1.74)	0.00 (1.67)	0.49 (1.57)	-0.26 (1.47)

For both policies, the level of impacts on lifestyle were higher amongst those who changed their behaviour compared to those who did not change. This is a logical outcome, as also revealed by a Spearman's rank correlation (explained in chapter 4) where the level of impacts were positively and significantly correlated with base carbon consumption for both policies ($p<.01$). In addition, for the TCP scheme behavioural response was also positively and significantly ($p<.01$) correlated with level of impacts on lifestyle. In terms of strength of impacts, for the TCP scheme the changers envisaged slightly less positive impacts than the non changers. This is largely explained by the view that non changers could benefit from improved public transport and/or from selling excess carbon permits (the majority of non changers were consuming within the free carbon permit allocation). In relation to the FPI, the non changers rated the impacts as being slightly negative whereas the changers had a neutral rating. This is largely a result of envisaged price increases of non-fuel products as a result of the FPI. It is interesting that many more respondents noted this impact in relation to the FPI than the TCP scheme and again demonstrates the different approach to thinking about/analysing the policy impacts.

6.2 Costs and benefits

Respondents were asked if there would be any costs and/or benefits to themselves and/or society as a result of the implementation of each policy. Responses were provided on a 7-point scale ranging from -3 (very many costs) to 3 (very many benefits). Table 6.4 contains the average ratings for each policy.

Table 6.4 Personal and social costs and benefits resulting from the TCP scheme and FPI.

	TCP scheme	FPI
Personal rating	0.34 (1.49)	- 0.43 (1.46)
Social rating	1.29 (1.64)	0.21 (1.81)

On average, respondents thought the TCP scheme would provide personal benefits, whereas the FPI would result in costs. However, the FPI would provide social benefits, but to a lesser extent than those provided by the TCP scheme. A Wilcoxon signed ranks test revealed a significant difference between the personal ratings ($p<.005$) given for each policy and also the social ratings ($p<.005$) given for each policy. However, the limitations of the sample size again appear apparent in the large standard deviation figures which prevent the direction of the average ratings from being ascertained. Hence, for further detail, the frequency of response is provided in figure 6.3.

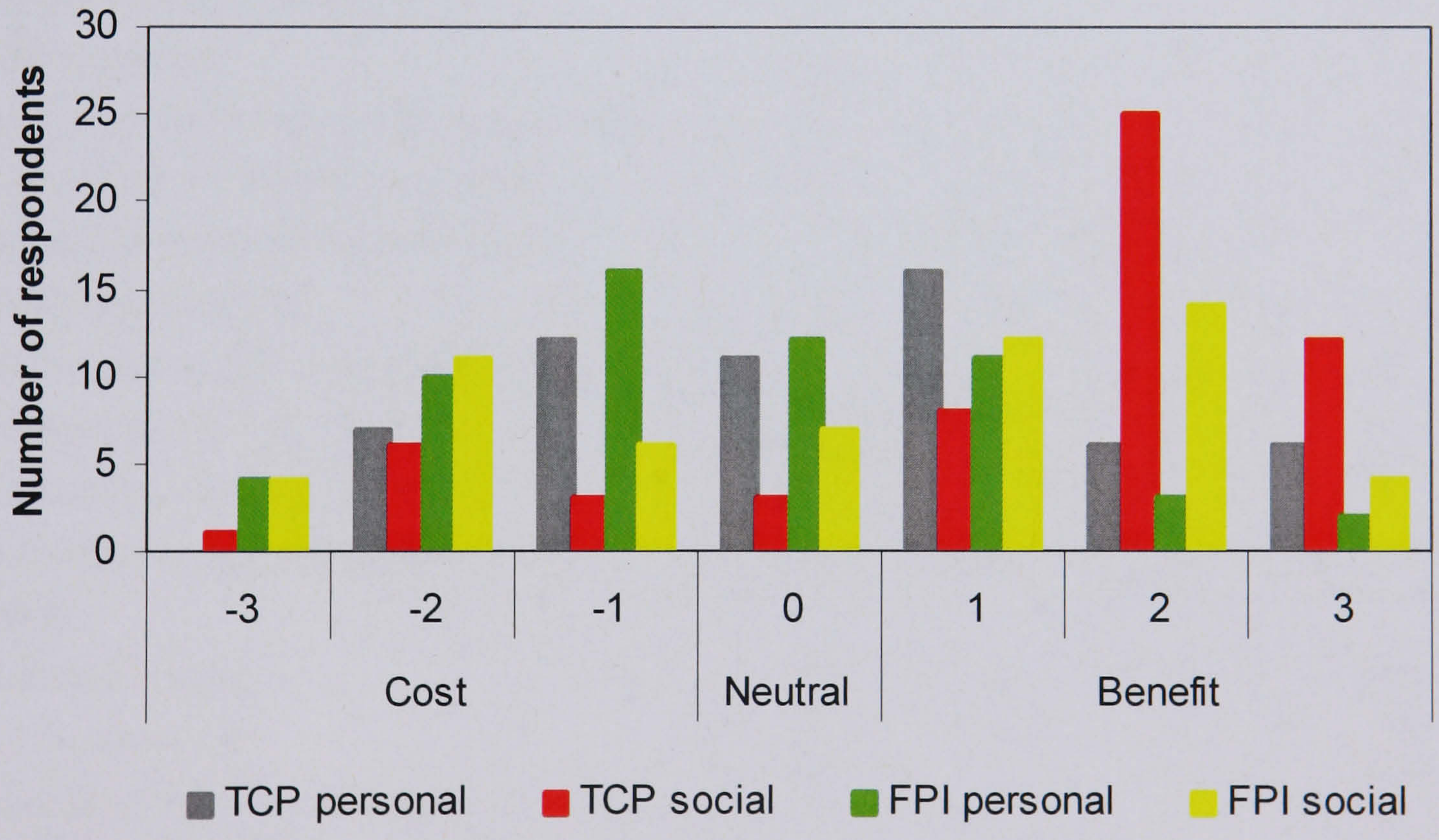

Figure 6.3: Costs and benefits

Figure 6.3 shows agreement with the average ratings in table 6.4 - a large variation in ratings with the majority of respondents envisaging personal and social benefits from the TCP scheme; and personal costs and social benefits from the FPI. Using an open question to investigate the reasons for these ratings, respondents were asked to explain their response which was recorded into categories during the interviews (as explained in chapter 3). Table 6.5 shows frequency of response in each category.

Table 6.5: Costs and benefits (number of responses) resulting from the TCP scheme and FPI

Issue	TCP scheme		FPI	
	Personal	Social	Personal	Social
Benefit				
Health benefits	11	11	3	9
Reduced levels of pollution	19	31	9	22
Social cohesion/integration	3	5	1	5
Time savings	3	3	2	1
Increase environmental awareness	9	12	2	1
Reduction in traffic congestion	8	24	5	11
Provision of clean fuel/vehicles		3		
Monetary benefit	9	1	2	
Improved public transport system		3	8	5
Increased fitness levels	11	7	4	3
Reduction in road accidents	1	4		2
Investment in local businesses	1	3	1	
Cost				
Monetary costs	17	8	35	25
Inconvenience	12	4	5	1
Negative impact on certain groups		3	2	6
Crime generation		4		
Reduced choice/freedom	3	2	5	4
Lifestyle changes	2	5	1	1
Increase social divisions			1	3

Complexity of policy	1	2		
Time costs	7	2	4	1
Non-investment of revenue on PT	1			2
Total number of benefits	**75**	**107**	**37**	**59**
Total number of costs	**43**	**30**	**53**	**43**

Table 6.5 shows for both policies that more social benefits than personal benefits were perceived. This is largely a result of reduced levels of environmental pollution and traffic congestion being considered as more of a social gain rather than a personal benefit. In terms of costs, more personal rather than social costs were perceived to result from both policies. This is largely explained by monetary costs and inconvenience being viewed as personal costs rather than costs to society. This clearly demonstrates a logical thought process - monetary costs might not apply to the whole of society whereas a reduction in pollution levels would benefit everyone.

The total number of costs and benefits reported in table 6.5 reflects the average ratings displayed in table 6.4 - for the TCP scheme there are net personal and social benefits whereas for the FPI there are net personal costs and net social benefits:

"People only lose out from the fuel price increase but people actually benefit from the permit scheme (35)*"*.

The most commonly stated personal benefits of the TCP scheme were a reduction in levels of environmental pollution (including local air pollutants, noise and greenhouse gases), health benefits as a result of reduced levels of air pollution (such as less incidents of asthma), and an increase in fitness levels as a result of an increased use of active modes (walking and cycling). A reduction in environmental pollution levels was also the most commonly reported personal benefit related to the FPI. An improvement in public transport services was the second most commonly reported personal benefit, which was not mentioned as a personal benefit in the TCP scheme despite a greater perceived increase in public transport use reported in chapter 5. This suggests that respondents were thinking of more important personal benefits arising from the TCP scheme, such as reduced levels of pollution, which were less prominent in relation to the FPI where more generic and widespread gains, such as improved public transport services were perceived. In addition, this also demonstrates the common opinion amongst the sample that the FPI would not generate a large reduction in car use, hence the benefits relating to this (such as health benefits due to reduced pollution levels) would be less apparent:

"Fuel prices are going up anyway so I can't see it having any impact (07)" and *"Not enough people will stop using their cars so there'd be little benefit, people would rather starve than stop using their cars* (32)*" and "We're all sat on the bus while the rich people are driving past and getting the benefit of getting to work quicker because there's less traffic on the roads* (24)" and *"It'd make it so that driving was something rich people do* (54)" and *"Well I'd have to spend more on fuel so that'd be a cost* (03)*"*.

This again demonstrates the difference between the policies - the TCP scheme stimulated respondents to reduce their carbon consumption sometimes at large costs (such as changing vehicles) whereas the majority of respondents were willing to absorb the increased fuel costs related to the FPI, rendering it as an almost invisible policy in terms of benefits provided.

The most commonly reported social benefits resulting from both policies were a reduction in environmental pollution and levels of traffic congestion, more so for the TCP scheme. A much larger number of respondents reported monetary costs arising from the FPI in comparison to the TCP scheme. This is largely a result of the perceived reduction in car and hence fuel use in relation to the TCP scheme in comparison to the general response of continuing current behaviour and absorbing the increased fuel costs in relation to the FPI (supported by behavioural response results provided in chapter 5). The majority of respondents felt that without any behavioural change the TCP scheme would impose greater monetary costs than the FPI as a result of the uncertain permit price, however this was perceived to be offset by a reduction in the consumption of fuel and thus permits (through a reduction in car use). Hence, the FPI was perceived to result in higher monetary costs due to a greater tendency to absorb the costs rather than change behaviour. This is also applicable to the social cost ratings where monetary costs were again more commonly reported in relation to the FPI than the TCP scheme.

Inconvenience was stated by a number of respondents in relation to both polices but to a larger extent for the TCP scheme. Respondents largely referred to the purchase of permits, monitoring of permit accounts and using permit swipe cards when purchasing fuel as an inconvenience, whereas for the FPI this was mainly thinking about car use reduction measures. As a result of the perceived amount of behavioural change in response to the TCP scheme, lifestyle changes were viewed by a number of respondents as a social cost. The generation of illegal permit markets was also stated as a social cost, given the possibility of jeopardising the carbon reduction target and hence the social benefits such as reduced levels of environmental pollution. Conversely, crime generation was not perceived as a cost resulting from the FPI:

"There'd be no incentive for a black market as fuel is available (03)*".*

The FPI was thought to have a negative impact on certain groups within society, such as rural dwellers and those on low incomes. It was considered that such groups were dependant on their cars possibly to an equal or greater extent than people on higher incomes or with greater access to public transport services yet would be subject to the same levels of fuel price increase. Conversely, this was thought to be less of a problem in relation to the TCP scheme as the free permit allocation was perceived to offset some of the negative impacts and inequities by allowing a certain amount of fuel to be purchased without any incurred additional costs. This again suggests the need for a form of revenue redistribution to be included in the FPI, which in turn stimulates the issues previously discussed in chapter 5 regarding the difficulty of making the redistribution fair and effective (i.e. without compromising the carbon emissions reduction target).

Several respondents noted the possibility of the TCP scheme instigating a cultural change away from car use:

"It'd be good because people couldn't build their lives around car use, they'd have to change and realise that you don't need a car to do everything. After a while they'd probably prefer it because they wouldn't be having the stress of driving everywhere (36)*".*

Many respondents felt that the increased use of public transport and local amenities such as shops would aid the cohesion of communities:

"If you're all at the bus stop together you'd get chatting to more people (28)*"* and *"I can imagine that people will see each other on the bus and sit and talk to each other* (25)*"* and *"When you go shopping now you don't really see people you know but if you were just popping down the street to do your shopping and everyone else was doing the same you'd see a lot more people* (30)*".*

It was also thought that the TCP scheme would provide a discussion point amongst communities that might as a result come together to discuss their intended course of action and share ways to reduce their permit use which might involve, for example, setting up local car pools:

"People would be more interested in what other people were doing because they'd know that if their neighbour was driving everywhere in their 4 by 4 there'd be less permits left for everyone else and they'd be more expensive. It could end up starting a community watch type of thing where frivolous use of

carbon is shunned upon. There might be things like community car clubs where they get together to decide who's the best person to car share with (52)".

Several of the costs and benefits listed in table 6.5 were related to behavioural change, thus table 6.6 shows the average ratings for perceived costs and benefits of both policies amongst those who changed their travel behaviour and those who did not make any changes.

Table 6.6: Costs and benefits – changers versus non changers

	Behavioural change		No behavioural change	
	TCP	FPI	TCP	FPI
Personal	0.06 (1.59)	-0.73 (1.10)	0.48 (1.45)	-0.36 (1.54)
Social	1.28 (1.67)	0.55 (1.86)	1.32 (1.64)	0.13 (1.81)

For the TCP scheme, slightly more benefits than costs were perceived amongst changers and non changers, with more benefits perceived by the latter. This is likely to be a result of an improvement in public transport services and the ability to sell excess carbon permits. The non changers also perceived slightly more social benefits compared to the changers. For the FPI, personal costs were perceived by both the changers and non changers, with more costs perceived by the former. This again demonstrates the different perceptions of the policies – the TCP scheme was thought to provide benefits to those who did not change their behaviour whereas the FPI was perceived to result in costs. However, both the changers and non changers considered the FPI to provide social benefits although to a smaller extent than the TCP scheme. Interestingly, in comparison to the non changers, those who changed their behaviour considered more social benefits to result from the FPI. This is possibly because the changers had fully considered the impacts in terms of reducing car use which in turn reduces congestion and air pollution – all of which would benefit society.

6.3 Fairness

Fairness appeared to be a key issue throughout the interview, as demonstrated in section 6.1 above where the rating of impacts to be positive or negative was largely affected by the number of people that were perceived to incur the same level of impacts. After considering the costs and benefits, respondents were asked how personally fair they considered each policy to be, and how society might rate the policies. Responses were given on a 7-point scale, ranging from -3 (completely unfair) to 3 (completely fair). The average ratings (with standard deviation) for both measures are shown in table 6.7.

Table 6.7 Personal and social fairness ratings

	TCP scheme	FPI
Personal	1.31 (1.42)	0.46 (1.87)
Social	- 0.61 (1.68)	- 1.38 (1.48)

The TCP scheme was considered more personally fair, and less unfair to society than the FPI. A Wilcoxon signed ranks test revealed a significant difference between the personal ($p<.005$) ratings for the TCP scheme and FPI and also between the social ($p<.005$) ratings for both policies. The standard deviation figures indicate a large variation in responses. Thus, the frequency of responses is displayed in figure 6.4.

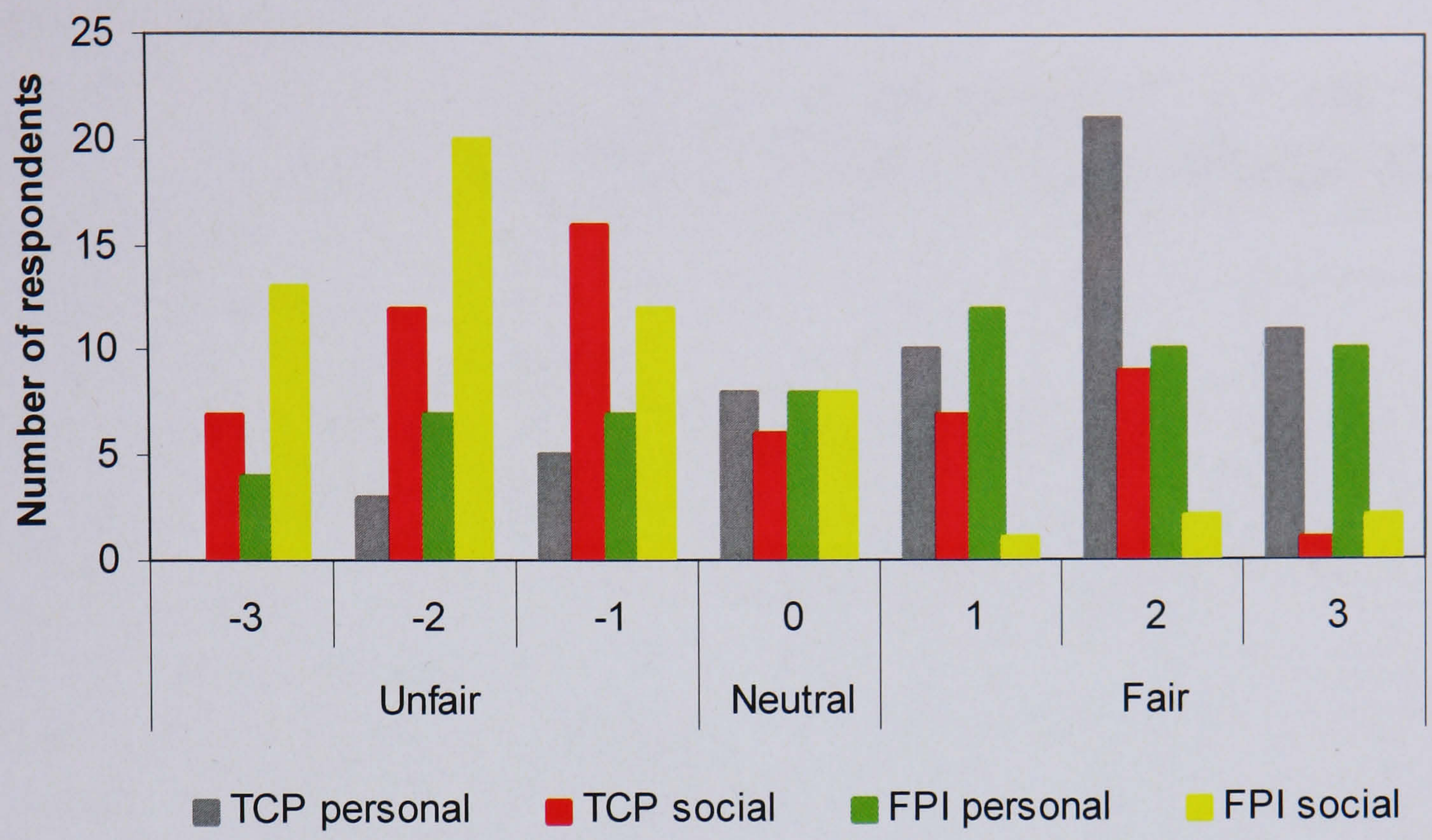

Figure 6.4: Perceived fairness

In agreement with the average ratings displayed in table 6.7, figure 6.4 shows the majority of responses regarding personal ratings of the TCP scheme and FPI were fair, whereas the majority of perceived social ratings were unfair for both policies. In order to investigate these ratings, table 6.8 provides the categories of responses interpreted from responses to open questions at this point of the interview.

Table 6.8: Fairness issues with number of responses relating to the TCP scheme and FPI

Issue	TCP scheme		FPI	
	Personal	Social	Personal	Social
Fair because....				
Policy is necessary	9	1	7	3
Allows current car use to continue			1	1
Everyone will be affected	3	2	1	
Increase environmental awareness	7	3	3	
Benefits[13]	8	5	1	1
Permit allocation	16	8		
Fuel should be more expensive	4		7	
Policy effective at achieving reductions	2	1		
Greater impact on high carbon consumers	7	1	2	
Can easily adapt current situation	4		1	
Unfair because....				
Uneven impacts across society	4	5	12	8
Increase social divide		2	2	3
Lack of trust in revenue use/policy aim		2	2	3
Fuel too expensive/monetary costs	3	14	4	27
Permit allocation		1		
Restriction on personal freedom	1	15		6
Black market/corruption	4	1		
Inconvenience of monitoring car use	3	2		
Lack of alternative travel mode	2	1	2	
Policy ineffective at achieving reductions			5	5
Total number of fair issues	**60**	**21**	**23**	**5**
Total number of unfair issues	**17**	**43**	**27**	**62**

The necessity to have a policy in place to effectively reduce carbon emissions from personal transport was a commonly stated reason for considering both policies to be personally fair. Jones (2003) also found during a survey amongst

[13] Includes health and fitness benefits from using active modes; reduced levels of traffic congestion and noise and air pollution.

the general public a common belief that 'something needs to be done', which was provided as a reason for accepting road pricing.

Respondents considered the allocation of carbon permits on an equal per capita basis to be a key factor in the fairness ratings of the TCP scheme, with those using more than their free allocation having to buy additional permits and therefore incurring extra costs. It was also felt that this would be the most common reason from a society viewpoint:

"*If everyone gets the same then there're no arguments are there* (54)" and "*If its been divided up equally then I think that's fair, I'd accept that that was my allocation and be happy to know that everyone else had the same amount* (01)" and "*It's like the polluter pays because if you use more than your free allowance you've got to start paying* (12)" and "*It gets people thinking about what they take for granted* (48)" and "*I'd be happy to stick to my allowance, it brings up the whole issue of social responsibility and I think it would feel good, like you were doing something to benefit society* (51)".

Many respondents also felt that the equal permit allocation provided a strong message that the problem is due to collective actions, affects everyone and requires collective action to mitigate:

"*It's saying we're all causing it and now we're all doing our bit to try and put it right* (39)" and "*It says that we're all in it together and we all need to make an effort* (06)".

It is possible that some respondents had not fully understood the TCP scheme, in terms of realising that the free permit allocation provided a certain amount of travel without increasing costs:

"At the end of the day it's like a fuel tax so it's still unfair (07)*"* and *"It could be seen as another tax so the benefits would have to be really emphasized* (25)*"*.

The necessity of the TCP scheme was also an important fairness issue, with many respondents feeling that emissions from personal transport should be reduced with the TCP scheme providing an effective option:

"It addresses the problem without just pricing people off the road with a financial disincentive (23)*" and "We need to do something and this seems like the most fair way. It should've been done earlier than this though because people are too used to their cars now* (45)*".*

The necessity to reduce emissions was also a major issue regarding personal and social fairness of the FPI:

"I think its unfair on me but I affect others so it has to be fair (12)*"* and *"I think the general public know that something needs to be done so they'd think it was fair overall* (39)*"* and *"If it's a government policy and we need it then I'll take part and shift my behaviour* (51)*".*

Several respondents felt that the TCP scheme would be considered unfair to society due to a perceived reduction of their personal freedom, with a limit on car use and thus their personal choices:

"It'd mean that they couldn't go and see their family when they wanted so no I don't think it's fair. There must be a better way to do it (58)*"* and *"I'd feel like I couldn't have the holidays I wanted because of this and that impinges on my personal choice. Other people would feel exactly the same* (16)*"* and *"People could see this as the government dictating that they can only do so many miles each year* (58)*"* and *"Society isn't as fully aware and switched onto environmental problems as it should be so the rating would be based on*

personal costs. People think climate problems are somebody else's, they don't want something that impinges on their personal choices (12)" and "*People see their car and freedom as a right. There'd be a lot of resistance and upset, the car gives people flexibility, freedom and safety. People need to be encouraged that it's a good idea rather than being told* (48)" and "*People don't like to change* (19)".

Civil liberties issues were also raised, in regard to the monitoring of the scheme, the national database containing permit accounts and the use of swipe cards when purchasing fuel:

"*It all seems a bit big brotherish to me, I'm not sure about it. It might be another way for the government to keep tabs on us, they'd know exactly what we were doing* (58)".

The purpose of data collection and use of the data collected through the central database would need to be transparent to the public in order to avoid any perception of conspiracy. The fact that the only data needed would be the time, date and location and quantity of permit use in addition to permit account balance and transaction records could possibly be made clear to the public in order to alleviate concerns that the government were 'keeping tabs' on people. As detailed in chapter 3 (see section 3.1), such accounts would be made confidential with monitoring only to detect any unusual activity.

In contrast, several respondents felt that, rather than restricting freedom, the TCP scheme actually provided choices:

"*This scheme puts people in control of their actions and has a big influence on personal decisions. It gives people choices and people would prefer to change on a voluntary basis* (50)".

It was also noted that the FPI could be viewed as providing choices and to a greater extent than the TCP scheme:

"There's a personal choice benefit with the fuel prices because if you want to carry on what you're doing you can if you pay more whereas the other scheme forces the change more so I think the fuel prices are more fair (07)*".*

However, as revealed in chapter 5, the option to continue current carbon consumption at increased costs could greatly jeopardise the achievement of the emissions target which increases the chance of the FPI policy being largely regarded as an unfair policy given the lack of effectiveness and thus becoming an 'unfair tax'.

A number of respondents noted the uneven distribution of impacts resulting from both policies. In relation to the TCP scheme:

"People with more money can buy more permits, it's as simple as that really (27)*"* and *"I'm sure that people would be able to buy as many permits as they wanted if they could afford it which isn't fair on everyone else* (08)*".*

In relation to the FPI:

"There'd definitely be an uneven distribution of benefits depending on income. People living in rural areas would be hit badly by this (FPI) (15)*"* and *"Low income people wouldn't be happy* (53)*"* and *"We'd have a situation where only rich people can afford to drive, it'd become really elitist, more than it is now* (36)*".*

It could be possible to redistribute revenue in order to reduce the worst inequities (see chapters 2 and 5 for further discussion).

Conversely, several respondents felt that the TCP scheme would result in equitable impacts:

"This is a much more equitable scheme across the whole socio-economic strata (12)*"* and *"It's more fair on lower incomes and it doesn't advantage the rich people* (36)*".*

The FPI was considered unfair by a number of respondents as it was perceived to be ineffective at achieving the emissions target:

"It won't work so how can it be fair? I'm willing to support things if they actually achieve what they set out to achieve (49)*"* and *"Fuel price has been going up anyway so I can't see it having any impacts* (41)*".*

Both policies were perceived to result in increased motoring costs, which were largely considered to be unfair as fuel was considered to be an already heavily taxed commodity:

"I think its really unfair actually because we already pay a lot for fuel, a lot more than other countries (57)*"* and *"I don't see how they could justify putting fuel prices up because they're already extortionate, they cant go any higher* (05)*"*

Many respondents felt that most people would largely view both policies as an additional tax rather than a measure to reduce CO_2 emissions, given the low levels of concern for the environment and climate change that were thought to prevail across society:

"People aren't concerned about the environment so they'd see this policy (FPI) as an unfair tax increase (41)*"* and *"People hate being hit in the pocket and they don't think it's the way to do it, it should be industry. They think car users shouldn't be punished because people can't change. They make excuses why*

it's unfair (36)" and *"People don't think they should pay more to use their cars because they can't see why it's wrong* (46)".

Conversely, a number of respondents felt that fuel should be more expensive in recognition of the detrimental impacts:

"People should pay for what they use (54)" and *"Fuel should cost more, I think it's too easy for people to drive judging by the amount of traffic on the road* (21)".

Several respondents noted the likelihood of varying public opinions related to the impacts of both policies, depending on personal circumstances:

"It would be fair to people that don't drive and unfair to people that do drive (55)*"* and *"I think there'd be a mix of opinions depending on how much extra it would cost and levels of car use* (56)*"* and *"Some people care about global warming, some don't care about global warming so I think the opinion would be mixed* (41)".

It was thought that fairness ratings might improve over time as people became accustomed to the TCP scheme and the benefits became visible. Several respondents thought that the public reaction was largely dependant on how the scheme would be portrayed by the media:

"If its all over the papers as a new policy to take away our cars and our civil liberties then people would definitely think it was unfair (04)*"* and *"It'd need to be backed by the media otherwise it might not even get off the ground. The papers could be used to tell people why it's fair and that it's not an excuse to watch everyone and take away our freedom* (13)*".*

Given the importance of fairness issues in terms of public acceptance of transport policies, as highlighted in chapter 2 (Jacobsson *et al.*, 2000; Fujji *et* *al.*, 2004; Viegas, 2001; Jones, 2005), an ordered Logit model was employed to further explore the relationships between fairness and other attitudes and socio economic variables. The discrete nature of the dependant variable (acceptability) violates the assumptions of linear regression, thus a log-linear approach was adopted. As the dependant variable is ordered rather than binary, an ordered regression analysis was considered most suitable. All variables collected during the study period were entered as ordered independent variables (impacts on lifestyle, costs/benefits, effectiveness, social fairness, personal and social acceptability, environmental concern, knowledge, problem perception, education, gender, income, age, carbon consumption, behavioural response), with the gradual removal of insignificant variables (at $p<.05$). Given the sample size and the clustering of responses away from the extreme ends of the scales, the variables measured on a 7 point scale were collapsed into 5 values where 1 represents the most negative ends (ratings of -3 and -2) and 5 represents the most positive ends (ratings of 2 and 3). 3 represents the neutral category. This process was carried out on all independent variables that were measures on a bipolar 7-point scale (impacts on lifestyle, costs/benefits, effectiveness, social fairness, personal and social acceptability). The variables were also reduced into 3 values in order to determine which method yielded the best model. However, the model fit data deteriorated when the variables were collapsed into 3 values.

By using the categories of each variable it allows the Logit model to provide a coefficient for each category of the independent variable, which shows the relationship with the dependant variable in comparison to the dummy independent variable, which in this model was the most positive end of the scale. For example, in terms of acceptability, the coefficients shown for categories 1 to 4 show the relationship with the dependant variable in comparison to the reference category. Hence, the coefficients in this model are expected to be negative as, for example in comparison to the most positive acceptability rating (category 5 – the reference category), fairness would be expected to decrease as acceptability decreases. The coefficients therefore would also be expected to display monotonicity (value increases/decreases consistently between categories), however in terms of the TCP scheme the coefficients of the significant independent variables are not monotonic. This could be explained by the low response for the value in the middle of the scales which represented the 'unsure' or 'neutral' responses. This could possibly be resolved by having a 6 point scale which excludes the 'neutral' option. However, this could result in respondents that are neutral or unsure selecting an inaccurate category. It is also possible that a larger sample size would reduce the problem. Table 6.9 provides the final models for both policies.

Table 6.9: Logit analysis of the determinants of personal fairness relating to the TCP scheme and FPI.

Independent variable	TCP scheme		FPI	
	Coefficient	P value	Coefficient	P value
Acceptability 1	-4.56	p<.005	-5.96	p<.001
Acceptability 2	-5.10	p<.001	-5.46	p<.001
Acceptability 3	-3.93	p<.025	-4.10	p<.001
Acceptability 4	-2.99	p<.001	-1.40	p<.001
Social fairness 1	-16.36	p<.001		
Social fairness 2	-17.50	p<.001		
Social fairness 3	-17.04	p<.001		
Social fairness 4	-16.47	p<.001		
Strength of impacts 1			-21.75	p<.001
Strength of impacts 2			-18.41	p<.001
Strength of impacts 3			-16.21	p<.025
Strength of impacts 4			-17.08	p<.025

TCP scheme

Pearson Chi-squared 47.5 -2 log likelihood 85.879 Pseudo R^2 .490

FPI

Pearson Chi-squared 131.4 -2 log likelihood 125.382 Pseudo R^2 .696

The degree to which a person considered the policies to be personally acceptable changed significantly from the reference dummy (which in this case was all ratings of maximum acceptability) to all other ratings of acceptability. Thus indicating that the degree to which a person finds the policy fair could be greatly related to the acceptability rating and vice versa. This is a logical relationship and has been investigated previously in relation to other transport policies (Jacobsson *et al.*, 2000; Fujji *et al.*, 2004). From the coefficient value it can be interpreted that the policies become less fair, or more unfair as the acceptability rating declines (going from acceptable (5) to unacceptable (1)).

From the coefficients related to the perceived social fairness ratings of the TCP scheme, it can be interpreted that personal fairness increases as social fairness increases. Whilst this is also a logical relationship, it was not identifiable from the average ratings displayed in table 6.7 where both policies were considered personally fair whilst being perceived by society to be unfair. This demonstrates the importance of using a variety of analytical tools when exploring responses.

The Logit model revealed for the FPI in terms of the strength of impacts on lifestyle, the difference in fairness was greatest between the reference dummy and the most negative impacts, hence fairness was lowest amongst those perceiving the most negative impacts.

The level of behavioural response appeared to influence responses throughout the interviews. Whilst behavioural response was not a significant factor in the Logit model of fairness, table 6.10 shows the average fairness ratings of both policies amongst those who changed their travel behaviour and those who did not make any changes.

Table 6.10: Fairness ratings – changers versus non changers

	Behavioural change		No behavioural change	
	TCP	FPI	TCP	FPI
Personal	0.94 (1.43)	0.82 (1.72)	1.43 (1.41)	0.43 (1.91)
Social	-0.22 (1.67)	-1.09 (1.70)	-0.73 (1.68)	-1.45 (1.44)

The TCP scheme was considered more personally fair amongst those who did not change their travel behaviour, whereas the FPI was more personally fair amongst the changers. In terms of social acceptability, the changers thought that both policies would be less unfair than the non changers.

6.4 Effectiveness

Following the fairness ratings, the perceived effectiveness (ability to meet carbon reduction target) was rated on a 7-point scale ranging from 0 (not at all effective) to 6 (completely effective). The average ratings, with standard deviations in brackets, are displayed in table 6.11.

Table 6.11: Perceived effectiveness ratings

TCP scheme	FPI
3.9 (1.4)	2.2 (1.4)

The TCP scheme was considered effective at achieving the emissions target whilst the FPI was considered less effective. A Wilcoxon signed ranks test indicated a significant difference between the effectiveness ratings of the policies ($p<.005$). However, the large standard deviation values again prevent a reliable interpretation of the average ratings, hence the frequency of responses are displayed in figure 6.5.

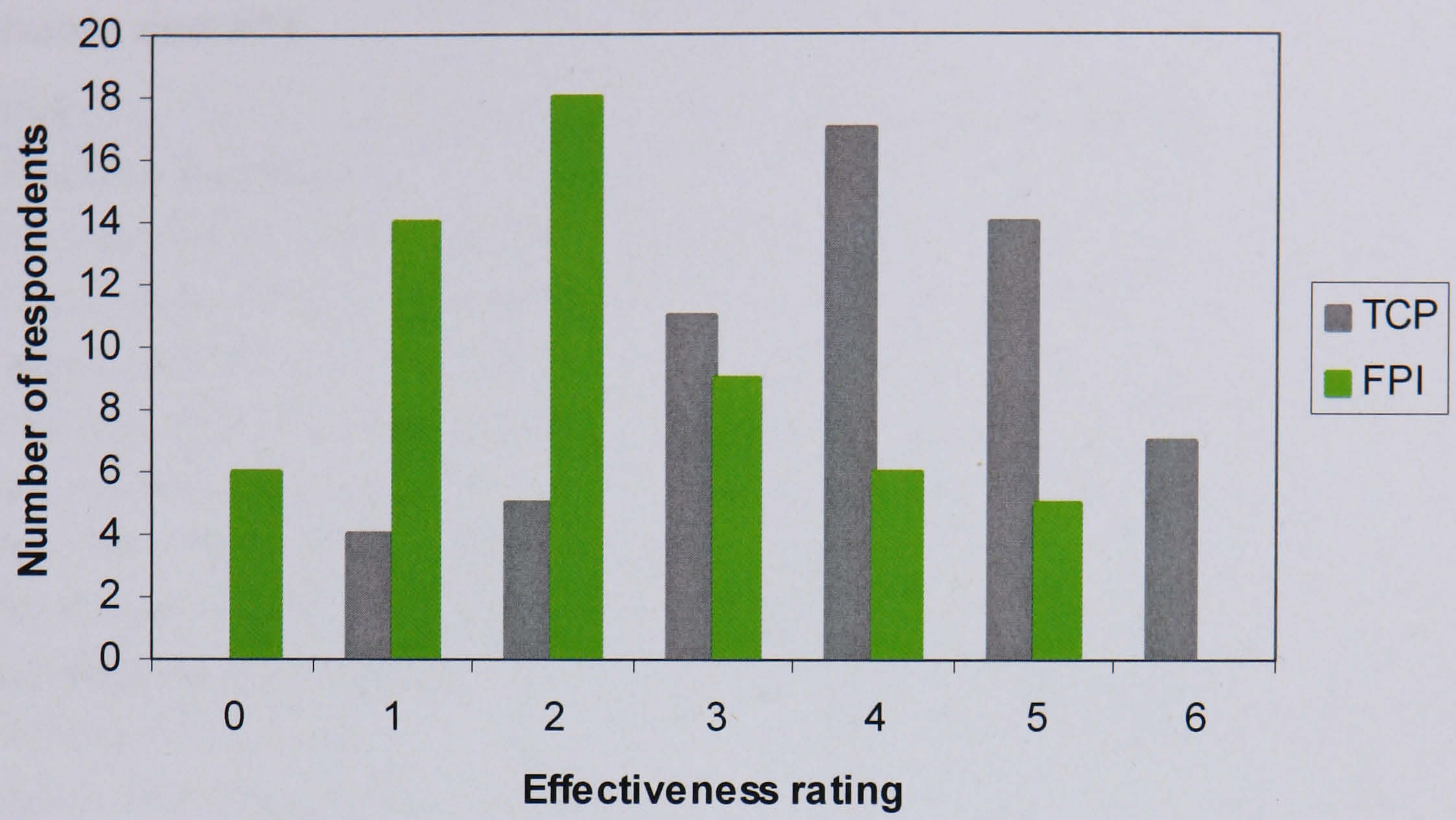

Figure 6.5: Perceived effectiveness

Figure 6.5 clearly shows that the majority of respondents rated the TCP scheme to be highly effective at achieving the emissions target whilst conversely the majority of respondents rated the FPI as being slightly effective. The perceived effectiveness of each policy emerged as a key aspect, underpinning the responses to several other questions, such as personal fairness as discussed in section 6.4. In order to investigate the perceived effectiveness ratings, table 6.12 displays the categories of responses derived from an open question with number of respondents.

Table 6.12: Issues relating to the perceived effectiveness of the TCP scheme and FPI

Issue	TCP scheme	FPI
Effective because....		
Policy increases environmental awareness	12	3
Places responsibility on individual	6	
Carbon budget ensures success	27	
Would be effective in long term		4
Non essential trips removed	3	1
Effective if people fully aware of policy purpose		1
Effective if reliable public transport provided	2	2
Ineffective because....		
Politically unfeasible	1	
Higher costs absorbed by majority	7	40
Difficult to monitor	2	
Lobbying/lack of faith in government	4	2
Counterfeit permits/fraud jeopardise target	9	
Price adjustments would be required	1	6
People not aware/interested in environment		1
Political instability	1	
Miss use of revenue		1
Total effective issues	**52**	**11**
Total ineffective issues	**25**	**50**

The majority of respondents felt that the TCP scheme would be effective at achieving the carbon reduction target due to the limit placed on carbon availability:

"If you can't go over the limit than it has to be successful (19)".

Several respondents were less sure that the TCP would be effective:

"I think the effectiveness remains to be seen. We'd just have to trust the government that it would work (28)".

A number of respondents felt that the TCP scheme would increase awareness of the environmental impacts associated with car use and would therefore reduce carbon emissions without needing to rely on the carbon limit:

"The permit allocation would encourage people to stay within the limit (05)" and *"It'd make people think about what they were doing because you've got your own allowance with a figure on it (27)"* and *"I think 80% of people would change. It'd make people think about their car use (25)"* and *"The trading scheme's got a more positive spin, people would adapt gradually and for environmental reasons (25)"* and *"People would be more aware of the purpose of the permit scheme because they'd be constantly reminded by having to use the permits. I think this'd make it more effective really. The purpose of the fuel price increase could get lost on people and it'd be seen as another unfair tax increase (04)"* and *"There'd be no extra costs if you stay within your limit* (47)".

Due to the limit placed on carbon availability, the TCP scheme could, theoretically, be 100% effective. However, several respondents were doubtful that the TCP scheme would be fully effective, perceiving complications such as the potential of fraudulent carbon permits jeopardising the carbon reduction target and a lack of faith in the government to carry out the policy:

"I can see some potential problems though like more carbon being released if there's a permit shortage which would breach the target but the government wouldn't want things to come to a halt (26)" and *"There's so much potential for abuse with this scheme, there'd be black markets all over the place. Another major issue is the fact that car use is engrained in society – the whole freedom of choice thing with people being able to go anywhere at will in a car which could possible make the policy politically unfeasible. It needs a climate that makes the scheme a non political party issue, like in response to a disaster* (51)" and *"There's a lot of issues to iron out that could potentially reduce effectiveness* (17)" and *"The government would increase the permit*

allocation because of increased pressure from the public (46)" and *"The scheme's too complicated, it's a hair brain idea for use on the general public, it'd be better for industry. It's a totally unworkable policy* (16)" and *"There's a possible problem of people selling their permits prematurely then needing to travel* (04)".

However, one of the main benefits of personal trading schemes is the placing of responsibility onto the individual (Starkey and Anderson, 2005; Fleming, 2007). Hence, each person would be responsible for managing their own carbon allocation and carbon permit use. In terms of budgeting issues, similarities can be drawn from managing a monetary budget which is applicable to the majority of adult individuals in the UK. This involves a degree of planning and self control which are transferable skills that could be applied to adapting to the TCP scheme. Several respondents recognised the benefits of placing responsibility on the individual:

"I think placing responsibility on the individual is very effective (10)" and *"The best way to make people aware of what they're doing is to give them some responsibility* (40)" and *"It's about time people were made to think about the consequences of their actions. This would make them realise how much emissions they were causing and to find ways of changing their behaviour. I think it could start a whole green thought process* (36)".

However, it should be considered that there is currently a record level of personal debt in the UK. Hence, it would be very important to fully consider the impact of loaning carbon permits and the consequences of allowing people to use their next years allocation in advance.

Whilst the TCP scheme was a new concept in terms of regulating personal transport emissions, respondents generally had more reservations regarding the effectiveness of the FPI highlighted by the greater number of 'ineffective' issues compared to the 'effective' issues listed in table 6.12. The majority of respondents felt that the public response to the FPI would largely be a continuation of current behaviour regardless of the price increase:

"*People'd complain but they'd still pay the extra* (45)" and "*Putting the price up doesn't work. People don't stop smoking because the price goes up, they stop smoking for other reasons* (11)" and "*It'd just be easier for most people to pay the extra cost and carry on rather than moving house or changing job* (52)" and "*I don't know because it's only a theory that it'll work. If people are well off they'll buy it* (49)" and "*People would just reduce their spending on other things so they could carry on buying fuel* (42)" and "*From my observations fuel price increases don't make any difference to consumption* (41)".

Several respondents felt that the FPI would be ineffective because the price increase was not high enough to stimulate a behavioural change:

"*You could get it to work by adjusting the price. If it's a government target then it would have to be met but the price would need increasing because it's too low* (33)" and "*A small price increase won't shock people into reducing their car use* (27)" and "*It's only a marginal change, it's not radical enough to achieve a savage reduction in energy use. People would just spend less in other areas* (51)".

Conversely, a number of respondents considered the price increase to be high enough but envisaged other problems related the policy that were thought to hinder the achievement of the carbon reduction targets:

"*The price is high enough to put people off but there's no limit on availability and there's no market influence to determine price therefore it can't be as effective as the trading scheme* (23)" and "*It wouldn't make people think about their consumption and address it. There wouldn't be a cultural change like there would with the permit scheme* (50)" and "*It doesn't provide a measure or make people think* (30)".

However, a number of respondents believed that the FPI would be effective at reducing carbon emissions:

"I think it'd be very effective. I think people would car share, walk for shorter trips and walk their kids to school (53)" and *"It'll make people think about car use because of the expense. Money's very important to people so it'd have a big impact on travel* (28)" and *"It'd work in the long term as long as incomes don't increase to counter balance it* (36)".

It is possible that respondents said the policies would be ineffective because they did not want to change their behaviour identified as strategic response by Rienstra *et al* (1999). Thus, to explore the affect of perceived effectiveness on behavioural response, ratings were averaged amongst those who changed their behaviour and those who did not make any changes. Table 6.13 shows the results.

Table 6.13: Perceived effectiveness – changers versus non changers

Behavioural change		No behavioural change	
TCP	FPI	TCP	FPI
4.17 (1.34)	2.27 (0.91)	3.80 (1.40)	2.15 (1.52)

For the TCP scheme, respondents who changed their travel behaviour rated the policy as more effective than those who did not make any changes to their behaviour. There are 2 possible explanations. Firstly, those who changed might have considered the policy more effective as they had changed their behaviour and thus thought that other people would do the same. Alternatively, those who did not change might have considered the policy less effective because it had not stimulated them to change and thus thought that other people might also not change. For the FPI, the average effectiveness ratings amongst changers and non changers are very similar – it therefore appears that behavioural response had little impact on perceived effectiveness.

After respondents had considered the effectiveness of each policy, they were asked to rate the impact on a list of factors. Responses were based on the perceived change (at a Great Britain level) in comparison with current circumstances using categories ranging from 'very much worse' to 'very much improved'. The responses were later given a numerical rating ranging from -3 (very much worse) to 3 (very much improved), with 0 as the 'no change' category. Table 6.14 displays the average numerical rating (with standard deviation) for each factor and policy, with the final column showing the difference between the TCP scheme and FPI average ratings.

Table 6.14: Affect of TCP scheme and FPI on various factors

Factor	TCP scheme	FPI	TCP - FPI
GHG emissions[14]	1.43 (0.89)	0.82 (1.02)	0.61
Local air pollution[5]	1.52 (0.82)	0.82 (1.12)	0.70
Local noise pollution[5]	1.22 (0.89)	0.63 (1.04)	0.59
Provisions of amenities	0.77 (0.89)	0.45 (0.96)	0.32
Public health	1.27 (0.87)	0.72 (1.02)	0.55
Traffic congestion[5]	1.42 (0.88)	0.71 (1.21)	0.71
Public transport	1.21 (1.00)	1.01 (1.10)	0.20
Access to amenities	0.54 (1.03)	0.27 (0.91)	0.27
Cost of private transport[5]	-0.58 (1.10)	-1.07 (1.24)	0.48
Social exclusion[5]	-0.07 (1.13)	-0.45 (1.11)	0.38
Frequency of accidents[15]	0.79 (0.89)	0.51 (1.03)	0.28

As shown by the difference between ratings, in all cases the TCP scheme was considered to have a more positive or less negative impact than the FPI particularly in relation to reducing local air pollution and traffic congestion. However, given the large variation in responses (indicated by the standard deviation values), tables 6.15 and 6.16 display the frequencies of response.

[14] An 'improvement' was interpreted by respondents as a reduction.
[15] An improvement in the frequency of road accidents meant a reduction in the frequency of road accidents.

Table 6.15: Effect of TCP scheme - individual ratings

Factor	Very much worse	Much worse	Worse	No change	Improved	Much improved	Very much improved
GHG				3	35	15	7
Air pollution				2	35	13	10
Noise				11	32	10	7
Local shops			2	22	28	4	4
Health				8	36	8	8
Congestion				4	38	7	11
Public transport				13	27	12	8
Access to amenities			10	17	25	5	3
Monetary costs	1	6	36	6	7	3	1
Social exclusion	1	4	15	22	16		2
Accidents			2	20	29	5	4

Table 6.15 clearly shows that the majority of respondents considered the TCP scheme to worsen the monetary costs of private transport. Conversely, all other factors were thought by the majority of respondents to be improved as a result of the TCP scheme, particularly levels of greenhouse gas emissions, local air pollution levels and traffic congestion, except social exclusion which was considered to remain the same as now.

Table 6.16: Effect of FPI - individual ratings

Factor	Very much worse	Much worse	Worse	No change	Improved	Much improved	Very much improved
GHG		1	2	20	27	5	5
Air pollution		1	5	17	24	8	5
Noise		1	4	25	21	5	4
Local shops		1	3	34	15	4	3
Health		1	1	27	21	5	5
Congestion	1	1	4	20	23	5	6
Public transport		1	3	15	25	10	6
Access to amenities			8	35	11	4	2
Monetary costs[4]	9	11	25	6	8	1	
Social exclusion	4	2	24	19	9	2	
Accidents[5]	1		3	30	20	2	4

Table 6.16 shows a majority of responses in the 'no change' category in relation to access to amenities, provision of local shops and road accidents. Conversely, public transport, greenhouse gas emissions, local air pollution levels, traffic congestion, health status, and noise pollution were considered to improve by the majority of respondents, whilst monetary costs and social exclusion would become worse as a result of the FPI.

It is clear from tables 6.15 and 6.16 that a greater number of respondents considered the FPI to result in higher monetary costs in comparison to the TCP scheme. Table 6.12 indicated that the majority of respondents felt that the public response to the FPI would be to absorb the increased fuel costs and continue current behaviour, hence the monetary costs would increase. The results shown in tables 6.15 and 6.16 therefore indicates that many respondents had possibly not taken into account unknown and possibly very high carbon permit prices which could increase beyond the relative FPI, despite being informed of this during the explanation of the TCP scheme. A greater number of respondents perceived social exclusion to worsen in relation to the FPI in comparison to the TCP scheme. This was largely a result of the perception that many low income motorists would be unable to continue their current behaviour and would thus be excluded from activities where car use is essential for access. In addition, the majority of respondents felt that the provision of local shops and services would remain the same as now rather than increasing to accommodate demand from those unable to continue current travel behaviour as a result of the FPI.

6.5 Alternative measures

Before the interview ended, an open question was used to ask respondents if there were any measures that they considered would more effectively achieve a 60% reduction in carbon emissions from personal road transport by 2050 than the TCP scheme or FPI. The measures suggested were categorised into policy type, as shown in table 6.17.

Table 6.17: Alternative measures to the TCP scheme and FPI

Measure	Number of responses
Pricing	
Road pricing	2
Increased Vehicle Excise Duty	1
Motorway tolls for freight	1
Infrastructure/technology	
More cycle lanes and facilities	1
Increased availability of clean personal vehicles	4
Work at home schemes/telecommute	1
Information/other	
Information on environmental impacts of car use	2
Advertisement of alternative vehicles/fuels	1
Car sharing	2
Improving public transport	6
Non tradable fuel ration	1
TCP on international scale	1
Policy combinations	
TCP scheme and public transport improvements	1
TCP scheme with subsidies on H^2	1
FPI and major public transport improvements	3
FPI with provision of alternative vehicles/fuels	1
FPI with improved fuel efficiency of vehicles	1
FPI with car use on certain days for each person	1
Congestion charging and PT improvements	1
Total	**32**

Overall, 40% of the sample considered another policy more effective than the TCP scheme and FPI. Improving public transport was the most frequently stated option. Reliability, frequency and route choice were the most commonly stated areas for improvement. Although public transport improvements were included in the policy descriptions of the TCP scheme and FPI, a number of respondents felt that improving public transport alone would achieve the emissions target, without the need for fiscal regulation provided by either the TCP scheme or FPI:

"People would use public transport if it was available (20)*".*

Whilst improving public transport alone would persuade a certain amount of people to reduce their car use, there would be no disincentive to influence the proportion of people who would inevitably switch back to car use as a result of reduced traffic congestion. In addition, improving public transport alone does not incentivise change amongst those most reluctant to switch mode, such as the 'malcontented motorists' and the 'complacent car addicts' (Anable, 2005). Whilst the suggestions in table 6.17 would undoubtedly have some effect on travel behaviour, many of them lack a driver for change. For example, increasing the availability of cycle lanes and clean fuelled cars. One respondent felt that the latter option would allow people to continue their current levels of car use and would thus be more preferable to the TCP scheme and FPI:

"We just need to use alternative fuels then people don't have to give up their car which is much more acceptable (48)*".*

However, within this option there are issues related to influencing purchasing behaviour and the sustainability of alternative fuels, particularly bio fuels and hydrogen produced from non renewable sources. It is doubtful that, without a driver to influence behaviour, a large enough change would be achieved from the use of alternative fuels alone.

Several respondents felt that the provision of information alone would influence behaviour enough to achieve the emissions target. One respondent felt that it was particularly important to change the way that people currently view public transport and car use:

"It's more about changing attitudes and norms towards car use and public transport (48)*".*

Several respondents felt that other forms of pricing would be more effective than the TCP scheme or FPI, although one respondent considered the TCP scheme to be more effective:

"Road pricing is most simple and easier to introduce on the basis of current technology but rationing is the way to go, plus it's the fairest policy (51)*".*

A combination of policy measures was suggested by a number of respondents. Interestingly, the majority of the combinations included the FPI despite this being rated as less effective than the TCP scheme according to the results shown in tables 6.11 and 6.14.

6.6 Conclusions and policy implications

The TCP scheme was more favourable than the FPI in terms of the strength of impacts on lifestyle, costs and benefits, fairness and perceived effectiveness, which is perhaps the most prominent research finding. The results presented in this chapter have demonstrated a diverse and varied range of opinions amongst the sample in terms of the issues raised regarding the impacts on lifestyle, costs and benefits, fairness and perceived effectiveness of both policies. The variation in response indicates that it would be very important to fully advertise all benefits of the policy at the implementation stage.

Whilst the level of impacts on lifestyle were perceived to be similar for both policies, the major outcome was the fact that the majority of respondents viewed the impacts resulting from the FPI to be negative overall whilst those resulting from the TCP scheme were positive. This difference was largely related to policy effectiveness and resultant fairness issues - many respondents felt that they would have to change their behaviour for both policies but the FPI provided an option for individuals to continue their behaviour at increased costs, thus resulting in fewer visible benefits due to failure to achieve the emissions target. Conversely, behavioural response to the TCP scheme was considered to be largely unavoidable due to the limit on carbon availability, hence respondents felt assured that most people consuming above their free permit allocation would have to make some changes, hence they would not be the only ones disadvantaged and in addition would gain benefits such as reduced levels of air pollution.

In terms of fairness ratings relating to the TCP scheme, the equal per capita basis of the permit allocation was the most prominent issue. A large number of respondents considered that everyone receiving the same amount of free permits was a fair approach. However, without a time allowance for discussing in detail the type and preference of various permit allocation methods during the interviews (such as increasing the allocation based on the number of dependants or instead providing children with an allocation), it could possibly be an insightful area for future exploration.

Collectively the results highlight perceived effectiveness as a major consideration in terms of responses given throughout the interview. For example, a popular opinion amongst the sample was that the public response to the FPI would be to largely continue current behaviour regardless of the price increase, which is supported by the behavioural response results reported in chapter 5. This belief was most apparent in relation to the effectiveness ratings where the majority of respondents considered such a response to result in a poor achievement of the carbon reduction targets. This factor was the main cause of the negative attitudes prevalent amongst the sample towards the FPI. For example, the FPI was thought to result in personal costs whereas the TCP scheme would provide net benefits. Hence, many respondents were unconvinced that the FPI would cause any significant changes whilst being convinced that the TCP scheme could deliver the reductions with a greater degree of certainty, which is a major finding from this chapter. Therefore, should the FPI be pursued as a policy option, it appears imperative to convince the public prior to implementation that the FPI would be effective. However, how to do this raises a range of questions, with particular regard to the lack of guarantee that the FPI would be effective without any restriction on carbon availability, as also noted by one respondent. This again raises questions regarding the suitability of the FPI as a carbon reduction measure, as also discussed in chapter 5.

The carbon budget was considered to make the purpose of the TCP scheme obvious on a daily basis and thus provide positive encouragement by increasing awareness of environmental issues and methods of carbon reduction. It is therefore possible that the purpose of the FPI could also be made more obvious and memorable on a day to day basis by introducing it as a carbon tax or levy rather than a fuel price increase, which is perhaps too emotive in that it is strongly associated with raising revenue for purposes which are not necessarily related to environmental improvements.

Whilst a large number of respondents had a positive attitude towards the TCP scheme in terms of achieving the carbon reduction targets, several respondents had strong reservations about the policy related to the possible availability of illegal carbon permits in addition to the complexities involved in monitoring and administration and political instability. Whilst such issues are addressed in chapters 2 and 3, they are valid concerns which require detailed investigation at the policy planning stage.

Chapter 7

Acceptability of the Tradable Carbon Permit scheme and fuel price increase

After respondents had considered their behavioural response and attitudes in terms of perceived fairness and effectiveness of both policies, the questions were focused on acceptability. Section 7.1 contains the acceptability ratings, which are explored in section 7.2. Although the majority of the explanatory work is achieved through the use of qualitative findings, an ordered Logit model is included in section 7.3. A comparison of the policies is then presented through an open question regarding preference between the policies in section 7.4. The support for including air transport in both policies is then presented in section 7.5. Suggestions from respondents regarding increasing the acceptability of the TCP scheme are then presented in section 7.6 followed by the chapter conclusions and policy implications in section 7.7.

7.1 Acceptability ratings

Respondents were asked to rate how acceptable they personally considered the policies to be and also to rate the polices from a wider social perspective. Responses were given on a 7-point scale ranging from -3 (completely unacceptable) to 3 (completely acceptable). Table 7.1 displays the average ratings of acceptability for both policies.

Table 7.1 Personal and social acceptability

	TCP scheme	FPI
Personal	1.14 (1.59)	0.32 (1.82)
Social	- 0.31 (1.45)	- 1.19 (1.61)

The results show that respondents considered both policies to be personally acceptable (more so for the TCP scheme), whilst both being unacceptable from a social perspective (the FPI to a larger extent than the TCP scheme). The ratings were tested for statistical significance using a Wilcoxon signed ranks test (used for ordinal data - see chapter 5 for more information). The personal acceptability ratings for the TCP scheme and the FPI were significantly different (p<.01), as were the social acceptability ratings (p<.005), thus implying that the difference between the ratings did not occur by chance.

The large standard deviation figures indicate that the average ratings could be positive or negative, thus to further examine the ratings, the frequency of responses are shown in figure 7.1.

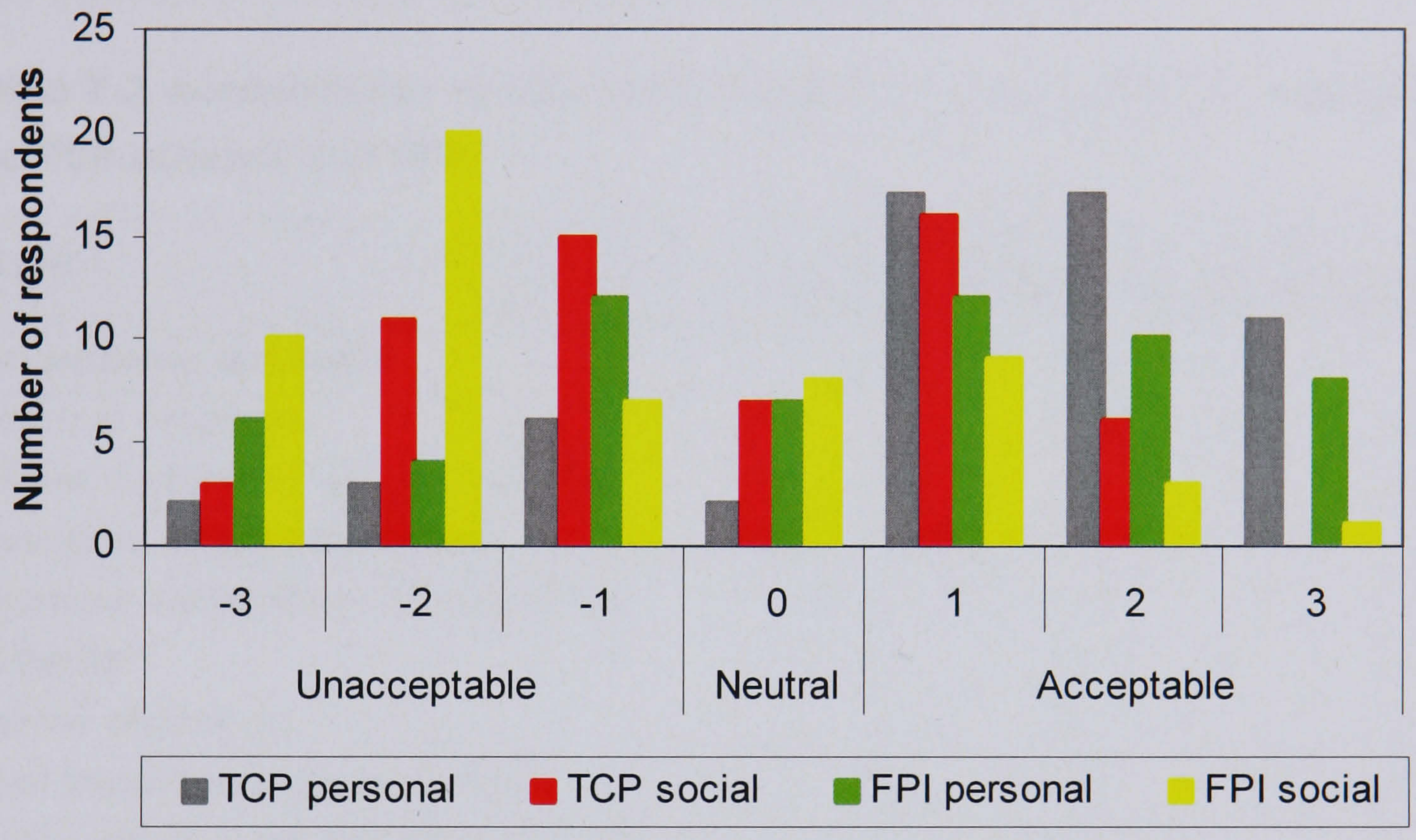

Figure 7.1 Acceptability ratings

In terms of personal acceptability, 78% of respondents considered the TCP scheme to be acceptable whereas 50% rated the FPI as acceptable. In terms of the FPI, this is greater than the average level of support (37%) expected for road pricing in the UK (Jaensirisak *et al.*, 2005). The TCP scheme is less comparable with road pricing than the FPI and is instead more comparable with findings from the RSA (2006) who found that 53% of respondents would accept limits imposed on their energy use if they helped to solve the problem of climate change. In which case, the acceptability of both the TCP scheme and FPI could be lower amongst a more representative sample. In terms of social acceptability, the majority of respondents thought society would consider the TCP scheme to be unacceptable, the FPI even more so.

7.2 Exploring acceptability: qualitative findings

Using an open question, respondents were asked to explain the reasons for their personal acceptability rating. Table 7.2 shows the responses.

Table 7.2 Acceptability issues (with number of respondents) related to the TCP scheme and FPI

Issue	TCP scheme		FPI	
	Personal	Social	Personal	Social
Acceptable because....				
Policy is necessary	13	4	8	1
Allows current car use to continue			3	1
Everyone would be affected	1			
Increase environmental awareness	7		2	
Benefits[16]	20	10	7	4
Permit allocation		3		
Fuel should be more expensive	3		7	
Policy effective at achieving reductions	4	1		
Can adapt current situation	5		1	
Improved public transport system			1	1
Fairness	11	4	1	
Policy would change peoples behaviour	4			
Fuel price increase is expected		1	2	2
Would not affect me	3		2	
Straightforward policy	2		2	

[16] The benefits included a reduction in air and noise pollution levels, health benefits resulting from such reductions, an improvement in physical fitness through the use of active transport modes, a reduction in traffic congestion and profiting from the sale of the free permit allocation.

Unacceptable because....				
Uneven impacts across society	1	4	3	1
Increase social divide		1	1	2
Lack of trust in revenue use/policy aim			1	
Monetary costs	2	14	10	32
Permit allocation/carbon budget		1		
Unfair	3	12	10	16
Lifestyle change		5		
Inconvenience of monitoring car use	1	3	1	
Lack of alternative travel mode alternative	2	2	1	2
Policy ineffective at achieving reductions	3			4
Complexity of policy	4	4		
Uncertainty of carbon availability		2		
Restriction of personal freedom/choice	3	7		2
Total number of acceptable issues	**74**	**23**	**36**	**9**
Total number of unacceptable issues	**19**	**55**	**27**	**59**

The total number of acceptability issues reported in table 7.2 reflect the average ratings provided in table 7.1. For the TCP scheme, there are more reasons given regarding personal acceptance of the policy in comparison to the FPI, whilst there are less reasons provided regarding social acceptability in comparison to personal acceptability for both policies. In terms of personal unacceptability, there are more reasons provided for the FPI in comparison to the TCP scheme whilst the number of reasons regarding social unacceptability is greater than personal unacceptability for both policies.

Table 7.2 shows that the perceived benefits were the main reason for personal acceptance of the TCP scheme. Whilst such benefits could also occur from the FPI, a much smaller number of respondents mentioned them. Conversely, the most commonly stated reason for accepting the FPI was the necessity to reduce carbon emissions:

"*We don't have a choice, we'd have to accept it because it'd be law and it's necessary* (28)".

Benefits were also one of the most commonly stated reasons, in addition to the feeling that fuel should be more expensive in recognition of the detrimental impacts. This again demonstrates the different ways of thinking about the policies as the feeling that fuel should cost more could also apply to the TCP scheme, however this was one of the least commonly stated reasons for accepting the policy.

Fairness and the necessity to reduce carbon emissions were two of the most commonly stated reasons for accepting the TCP scheme:

"It's a fair way to reduce emissions, it improves public transport and encourages people to use it. I think the scheme would work well and has a target and aim to achieve and it's a big scheme for people to take on which would help to make people realise the scale of the problem and what needs to be done (46)*"*.

Many of the fairness issues discussed in chapter 6 (see section 6.3) were again highlighted during the responses to the acceptability questions. The majority of comments were regarding the impact of the TCP scheme in terms of everyone being affected, the limit on carbon availability and the equal per capita permit allocation. In addition, several respondents noted the possibility of a general movement towards smaller vehicles in order to reduce carbon permit consumption.

In terms of social acceptability, benefits were again the most commonly stated reason regarding public acceptance of the TCP scheme. Perceived benefits were also the most commonly stated reason for social acceptance of the FPI but to a much lesser extent:

"It's a small price increase so I don't think people would object considering the benefits received (55)*"*.

Amongst the respondents rating the TCP scheme as unacceptable, the most commonly stated reason was the perceived complexity of the policy in terms of managing a permit account and allocation, buying permits and calculating permit consumption of car journeys. Several respondents also felt that the TCP scheme would be unfair due to a perceived reduction in leisure journeys. In addition, several respondents had concerns over the effectiveness of the policy and were unconvinced that the carbon reduction targets would be achieved. A restriction on personal freedom was also an issue for several respondents who felt that their choices would be constrained by the TCP scheme. However, one respondent had the opposite opinion:

"*It's about reducing your footprint, not about reducing your choices* (12)".

In terms of the FPI, unfairness together with monetary costs were the most commonly stated reasons for rating the policy as unacceptable. A number of respondents felt that the FPI would be unfair largely because they were doubtful that the carbon reduction targets would be achieved:

"*There'd be no benefit or change therefore it wouldn't achieve anything which makes it unfair* (06)" and "*It's a risky way to do it because it might not work whereas the trading scheme has set targets but may be less socially acceptable* (49)" and "*It's another way of increasing taxes without necessarily providing benefits. Fuel price has gone up due to oil price increases and there's been no impact on behaviour* (47)" and "*There's a high risk that it won't work and could be for nothing. There'd be no benefit and people paid more for nothing* (43)" and "*It's just a stop gap approach, the government trying not to do too much and cause too much upset. People can ignore the prices, they're too low* (35)" and "*I think it's unfair because I don't believe that the government would use the revenue to improve public transport. It'd be acceptable if they did* (15)".

Unfairness and monetary costs were also the most commonly stated reasons in terms of the perceived social unacceptability of both policies. In relation to the TCP scheme:

"People don't want to cycle or walk or be dictated to. They'd find it intrusive (35)" and *"People love their cars too much and aren't concerned about global warming so they'd think it was unfair* (30)" and *"People are too selfish to accept it, they think they've got a right to drive everywhere* (16)" and *"I think whether or not people can make their essential trips within their permit allowance would decide how acceptable it is* (11)" and *"People would think it's the worst thing that could happen to them* (10)".

In relation to the FPI:

"People don't want to pay more for fuel, they don't want to pay more tax for the NHS and schools so they won't want to pay more for fuel (30)" and *"If you can afford it great, no problem if you can't then tough you have to reduce your use (48)" and "It'd just be seen as another tax* (8)" and *"People can't see pollution, they're not concerned"* and *"People realise something needs to be done but not by having to pay more* (16)" and *"People wouldn't like it. They'd say that fuel is already too expensive and we pay more than other countries and why should we change when America won't reduce their emissions* (33)" and *"It'd become more unacceptable over time as the price increased and people were unable to absorb the costs* (25)" and *"It's more of an impact because people feel more coerced to changing their lifestyle and they don't like that* (36)" and *"They think their journey won't make a difference, it's everyone else* (54)".

Several respondents felt that such feelings of unfairness from society would be unjustified, in relation to the TCP:

"To limit personal freedom is to help the planet which I think is necessary (5)".

In relation to the FPI:

"*People need to be encouraged to stop using their cars which requires some form of coercion* (16)".

Several respondents felt that the TCP scheme would become more acceptable over time:

"*People wouldn't like it at first but they'd get used to it. It's like the seatbelt law. It becomes more acceptable over time* (05)" and "*I don't think people would like it at first but after a while they'd notice the benefits so I think it would be acceptable over time* (45)" and "*I think initially it would be unacceptable probably because there's a limit but as people adjust and they see changes in the midterm acceptability would increase* (49)" and "*People think they're dependant on their cars but over time they'd find it acceptable and reduce their use. People don't think they can adapt but over time they'd realise they can change. It's like smoking, no one thought that'd ever be banned but now it is* (36)".

It is highly possible that the acceptability of the TCP scheme would change following implementation when the benefits become visible. For example, support for the London congestion charging scheme increased from 39% prior to implementation to 59% following implementation (TfL, 2004). It is also possible that the FPI would become more acceptable over time, however this was not mentioned by any respondent. During the interviews a number of respondents found it difficult to rate their responses using the 7-point scales as they thought their opinion would change in the long term, for example, benefits would increase in the long term as pollution levels declined but initially the policy might result in costs, for example having to reduce car use and/or buy carbon permits. Hence, based on the discussions during the interviews it is likely that the acceptability of the TCP scheme would increase rather than decrease over time.

Following the explanation of their personal acceptability ratings, respondents were asked which factor was of most importance when making their decision. Table 7.3 displays the responses with number of respondents.

Table 7.3 Issues of most importance relating to personal acceptability of the TCP scheme and FPI (with number of respondents).

Issue	TCP scheme	FPI
Policy is necessary	12	4
Allows current car use to continue		3
Increase environmental awareness	2	3
Benefits	15	7
Permit allocation	1	
Fuel should be more expensive	1	3
Policy effective at achieving reductions	8	
Can adapt current situation	2	4
Uneven impacts across society	1	
Policy is fair	9	
Monetary costs	3	8
Restriction on personal freedom/choice	1	
Policy is unfair		4
Inconvenience of monitoring car use	1	
Lack of flexibility	2	1
Policy ineffective at achieving reductions	1	11

Table 7.3 shows that the most important reason for rating the TCP scheme and FPI as acceptable was the perceived benefits, which includes a reduction in air pollution and traffic congestion. Following this, the necessity to reduce carbon emissions and the consideration that the TCP scheme was fair and effective at reducing carbon emissions were the most commonly stated reasons regarding acceptance of the TCP scheme. In relation to the FPI, the perceived benefits, the necessity to reduce emissions and the ability to adapt travel behaviour with little inconvenience were the most important reasons regarding acceptance. In terms of rating the policies as unacceptable, monetary cost was the most

important factor relating to the TCP scheme whilst the inability to achieve the carbon reduction targets was the most important reason regarding the FPI.

The frequency of responses displayed in table 7.3 again demonstrates the difference in attitudes related to the policies – the most commonly stated issue related to the acceptability of the TCP scheme was the perceived benefits which are positive and related to acceptance. Conversely, the most commonly stated issue regarding the acceptability ratings for the FPI was the inability to achieve the emissions target, which is negative and related to non acceptance of the policy.

7.3 Exploring the determinants of acceptability: quantitative findings

Given the importance of acceptability in transport policy (Jones, 1995; 2003; Whittles, 2003; Schade and Schlag, 2003; Button and Verhoef, 2000; Jaensirisak *et al.*, 2005), an ordered Logit model was used to further investigate the influential factors (see section 6.3 for an explanation of the model). All variables collected in the interview questionnaire were included as discrete independent variables (level of impacts on lifestyle, costs/benefits, effectiveness, personal and social fairness, social acceptability, environmental concern, knowledge, problem perception, education, gender, income, age, base carbon consumption, behavioural response (entered as a binary variable with 1 representing a response during one or more time periods and 0 representing no change during any time period)), which were gradually removed from the model based on significance ratings ($p<.05$). Thus, each time the model was re run, the least significant variable was removed until all of the variables in the model were significant. The same method of categorical data analysis was used by Rienstra *et al* (1999), Jakobsson *et al* (2000) and Fujii *et al* (2004) for exploring the determinants of the acceptability of road pricing. In addition, to investigate the impact of this method of variable removal, several models were run based on logical combinations of independent variables such as carbon consumption, concern for the environment and income. Each combination investigated yielded insignificant variables and very low r^2 values. Table 7.4 shows the model derived from the gradual removal of variables based on significance ratings.

Table 7.4: Ordered Logit model of the determinants of personal acceptability relating to the TCP scheme and FPI

Independent variable	TCP scheme		FPI	
	Coefficient	P value	Coefficient	P value
Personal fairness 1			-7.974	p<.001
Personal fairness 2	-4.418	p<.005	-4.681	p<.001
Personal fairness 3	-6.028	p<.001	-3.271	p<.001
Personal fairness 4	-4.060	p<.005	-1.666	p<.050
Personal cost/benefit 1	-7.692	p<.001		
Personal cost/benefit 2	-5.862	p<.001		
Personal cost/benefit 3	-3.131	p<.050		
Personal cost/benefit 4	-4.373	p<.010		

TCP scheme

Pearson Chi-squared 58.179 -2 log likelihood 105.24 Pseudo R^2 .60

FPI

Pearson Chi-squared 96.044 -2 log likelihood 82.487 Pseudo R^2 .54

In terms of the TCP scheme the coefficients of the significant independent variables are not monotonic as would be expected (see section 6.3). This could be explained by the low response for the value in the middle of the scales which represented the 'unsure' or 'neutral' responses. It is possible that a larger sample size would reduce the problem.

The Logit model shows that acceptability of the TCP scheme is greatest where benefits and personal fairness also have the highest ratings (categories 1 to 4 have a negative coefficient in comparison to the reference category 5) (there were no responses for personal fairness 1). These results are supported by table 7.2 which showed that perceived benefits were the most commonly stated reason for rating the TCP scheme as acceptable and were also predicted in the research hypotheses (see chapter 3 - section 3.4). In addition, table 7.3 revealed that benefits were the most important factor in terms of acceptance ratings. Fairness was the third most commonly stated reason for accepting the policy in tables 7.2 and 7.3 (necessity of the policy was the second most commonly stated however there is no variable in the model to account for necessity). Schade and Schlag (2003) found using a stepwise multiple regression analysis that personal outcome expectations (benefits) were positively related to the acceptability of transport pricing strategies.

Personal fairness was revealed as the only significant independent variable in terms of acceptability of the FPI. In this case the coefficients show a monotonic relationship (consistently become more negative between categories), thus indicating that the FPI becomes more acceptable, or less unacceptable, as personal fairness ratings increase. This correlates with the results in table 7.2 where unfairness was one of the most commonly stated reasons for rating the FPI as unacceptable. In addition, the Logit model results are in line with findings by Jakobsson *et al* (2000) who discovered that the acceptance of road pricing was negatively affected by perceived infringement on personal freedom and unfairness. These results were further confirmed by Fujii *et al* (2004), where fairness was discovered to be the main predictor of acceptability of road pricing. Further to this, Eriksson *et al* (2006) revealed that moral considerations and perceived fairness were the most important factors in terms of the acceptability of fuel tax increases.

It is possible that there is a multi causal relationship in terms of perceived fairness and acceptability - chapter 6 revealed that the strength of impacts on lifestyle (positive/negative) was one of the main predictors of fairness for the FPI (see table 6.9). Hence, the fairness ratings included in the acceptability Logit model were likely to have already accounted for costs and/or benefits.

7.3.1 Acceptability and behavioural response

The acceptability ratings were explored in terms of behavioural response. Table 7.5 shows the average ratings of personal acceptability amongst the respondents who changed their behaviour during one or more time periods and those who made no changes to their travel behaviour.

Table 7.5: Acceptability – changers versus non changers

	Behavioural change		No behavioural change	
	TCP	FPI	TCP	FPI
Personal	1.44 (1.19)	0.64 (1.50)	1.00 (1.74)	0.30 (1.89)
Social	0.22 (1.31)	-0.27 (1.56)	-0.55 (1.47)	-1.19 (1.58)

For both policies, the changers had slightly higher ratings of personal acceptability than the non changers. This suggests that behavioural response would increase amongst those rating the policy as acceptable or vice versa. This is plausible as it is perhaps likely that acceptability would increase amongst those who are able and/or willing to change their behaviour and decrease amongst those less willing and/or able to change. In terms of perceived social acceptability, those who changed for the TCP scheme thought that the general public would rate the scheme as slightly acceptable whereas the non changers thought the general public would consider the scheme to be slightly unacceptable. For the FPI, both the changers and the non changers thought that society would rate the policy as unacceptable, more so amongst the non changers.

7.4 Direct comparison of the TCP scheme and FPI

Following the questions relating to each policy separately, respondents were asked which policy they considered to be most personally acceptable. The majority of respondents (40) would consider the TCP scheme to be more acceptable than the FPI, 1 respondent thought the policies were equally as acceptable, 1 respondent thought neither were acceptable and 18 respondents considered the FPI to be more acceptable than the TCP scheme. Table 7.6 displays the categories of responses derived from an open question at this point of the interview.

Table 7.6 Comparing acceptability of the TCP scheme and FPI

Issue	TCP scheme	FPI
Fairness	16	2
Allows current car use to continue	2	8
Everyone would be affected	2	
Increase environmental awareness	10	
Benefits[17]	5	
Permit allocation	1	
Less financial costs	3	
Policy more effective at achieving reductions	24	
Greater impact on high carbon consumers	1	
Carbon budget	2	
Revenue raising potential		3
Would not have either scheme	1	
Focus on individual	1	
Personal choice element	2	6
Simplicity of policy		4
Would make people change	3	1

Table 7.6 shows that the main reason for considering the TCP scheme to be more acceptable than the FPI is the ability to achieve the carbon reduction targets:

"People can't ignore the trading scheme but they can ignore the fuel prices (23)" and *"The trading scheme has a bigger impact even though it's more*

[17] Includes health and fitness benefits from using active modes; reduced levels of traffic congestion and noise and air pollution.

difficult than the fuel price increase. The trading scheme is the way we should go (27)" and "*People would consider it in the same way as a personal bank account which has a limit and each time they're buying fuel they'd think about their bank balance going down* (49)"

Fairness was also commonly stated:

"*It provides incentives to change instead of penalising people for doing the wrong thing* (44)" and "*It gives rewards to people that are already doing something positive like using public transport* (30)" and "*It gives people fair access to resources to use and is not based on ability to pay. Fuel price increases are regressive* (51)".

Increasing public awareness of environmental issues was also a commonly stated reason for considering the TCP scheme more acceptable then the FPI:

"*It's a softer approach and makes people conscious of what they're doing. The permit scheme has a good approach because it works with people and treats them as adults* (36)" and "*It'll change public attitudes, it'll be frowned upon to over use your car the same as not recycling glass bottles* (14)" and "*It makes people think about car use and increases personal responsibility in managing the allocation* (28)".

In terms of the FPI, the most commonly stated reason for preference over the TCP scheme was the ability to continue current behaviour, albeit at increased monetary costs. This was considered to provide an element of personal choice:

"*There's no limit on consumption so there're more options. I can still do the journeys I want and can afford to pay the extra. It's more fair then the trading scheme* (33)" and "*There's no element of compulsion and it'd work if nice cars with lower fuel consumption were available* (52)".

The simplicity of the FPI and the revenue raising potential were also commonly stated reasons:

"It provides immediate investment into public transport. The trading scheme's too complicated for the general public and people might think it's a waste of time and money if it's not understood (53)" and *"Fuel price increases anyway but at this level it would make people think about their journeys and car use* (40)" and *"I think the public would see the permit scheme as a waste of money that could be spent on something else like the Supertram. The fuel price increase is a simple policy, there's no more bureaucracy involved than there is now and all the revenue could be spent on improving public transport* (16)".

7.5 Air transport

In recognition of the importance of air transport in terms of carbon emissions (Bows and Anderson, 2007) (see chapter 1), respondents were asked whether they thought air transport should be included in the TCP scheme and FPI, and whether they would alter their current use of air transport if it was included. In relation to the TCP scheme, 83% of respondents stated that air transport should be included:

"It'd make operators increase their fuel efficiency so it'd be more of an investment than a cost (13)" and *"It should be included. Air transport is a major problem* (28)".

A number of respondents did not think that air transport should be included in the TCP scheme:

"International issues make the scheme too complicated (06)" and *"I'm not sure about alternative fuels for aircraft, it's a long and slow process. I think including it would cause problems, air transport needs different solutions. It'd be unfair if I could only fly once a year* (55).

In relation to the FPI, 77% stated that air transport should be included:

"I think its more effective for air transport than road transport because it's less essential (45)" and *"I think it should be included because air travel is more of a luxury that you can do without whereas car fuel is more essential. I wouldn't like it though but I'd just save up more money for my holiday* (11)".

A number of respondents felt that air transport should not be included in the FPI mainly because it was considered to be ineffective at reducing carbon emissions and/or unfair to increase air fares:

"It wouldn't be effective, people would just get into more debt going on holiday (35)" and *"The price increase would have to be much higher* (44)" and *"It'd have to be a landing fee instead because they'd just fill up aircraft with fuel in another country* (16)" and *"Holiday makers only use air about twice a year anyway so I don't think it'd be fair to include it* (56)" and *"It depends on the price increase. It might make holidays for the elite again* (08)".

Respondents were then asked if they would alter their use of air transport if it was to be included in the policies. The responses to this open question were categorised and are shown in table 7.7.

Table 7.7 Response to the inclusion of air transport in the TCP scheme and FPI

	TCP scheme	FPI
Fly less often	19	21
Have holidays in the UK	2	3
No change	39	37
Use alternative transport mode	3	3
Think about journey length	5	1

In response to both policies, the majority of respondents would not change their use of air transport which can be largely explained by a number of respondents who either did not use air transport or were very infrequent users. However, in relation to the TCP scheme, several respondents recognised the possibility of using permits for air transport that they had saved from changing their use of land based transport:

"I'd buy a clean fuel car so I could use my permits for flying (08)" and *"I'd use my road transport permits that I'd saved by cycling* (35)".

For those that would change, the most commonly stated response was to reduce the number of flights taken. This was mainly in reference to leisure trips taken to other European countries over the weekend. A small number of respondents would consider having their annual holidays in the UK rather than flying to another country:

"I think I'd have my holidays in this country and travel by train (45)" and *"It'd definitely make me think about it more* (16)".

The majority of respondents were unwilling to alter their main annual holiday:

"Flights are too cheap and it'd be better for the environment if they were less available and more expensive but I wouldn't sacrifice my holiday every year (33)" and *"I'd feel really reluctant, air travel is very personally important so I'm not keen on limiting my personal air travel. I'd feel imprisoned. We should just get clean fuel planes* (48)".

7.6 Increasing acceptability of the TCP scheme

Following the acceptability ratings of the TCP scheme, respondents were given the opportunity to state whether they would alter any aspect of the policy. The responses to this open question were categorised and are displayed in table 7.8.

Table 7.8 Making the TCP scheme more acceptable

Issue	Number of responses
Technological/design related	
Varied permit allocation	18
Include permit banking	2
Disallow sale of excess permits	1
Permit price premium over set consumption	3
Include all domestic energy	3
Permit trade between individuals	1
National emergency permit fund	1
Reduce timescale of policy	2
Not provide free allocation	2
Supportive measures/incentives	
Reward for using PT	3
Subsidies for clean fuel vehicles	2
Subsidise provision of clean fuel and vehicles	2
Extensive information provision	3
Reward for not using full allocation	1
Limit vehicle engine size to reduce consumption	1
Reduce price of fuel	1
Cap on fuel price	1
Other	
Would not implement TCP scheme	2

The most commonly stated amendment to the TCP scheme was to alter the permit allocation:

"*Public transport users get less. Car dependant people get more but only if it's used wisely* (28)" and "*I think the allowance should be linked to your job type, where you live, who you live with, and your income* (45)" and "*It should be a varied allocation on a needs basis looking at car dependency and children.*

Adults get more than children but the child allocation would increase with age (29)" and "It's not fair to give everyone the same allocation (26)" and *"You'd need exceptions for different groups with more for people with children. It'd get the parents on board. There'd be smaller allocations for pensioners because they don't need as much* (25)" and *"It should be means tested like the car parking permits at university. It'd be based on how long the car journey is by public transport and whether there're any children to drop off or collect* (33)" and *"The allocation should be based on vehicle type* (03)" and *"Means test the allocation so that people that don't use carbon wouldn't get an allowance and people with children get more* (14)" and *"Give more free permits at first then reduce the amount and make it a more harsh reduction after 10 years* (48)".

Whilst the equal per capita permit allocation was the most commonly stated reason for considering the TCP scheme fair (see chapter 6 - table 6.8), there was clearly a wide variation in suggestions regarding the allocation of permits. Research conducted by the RSA (2006) found that the majority of respondents (46%) thought that people in 'special needs' groups, such as the elderly, should have the right to consume more energy rather than consumption being limited equally across society. It is highly possible that reaching a consensus agreement on one type of permit allocation would be unachievable – for example, the suggestion that pensioners require fewer permits could possibly be a contentious topic. Similarly, whether or not to give children allocations is likely to differ amongst people who themselves have children and those who do not. Therefore, types of permit allocation and preference could be an important area for future research.

One respondent felt that the timescale should be reduced:

"I'd reduce the timescale to see the benefits sooner and therefore make it more acceptable. People would like to see changes sooner (49)".

Several respondents felt that the TCP scheme should include all domestic energy:

"People could use their permits for heating then if they used the bus (11)".

Inevitably there would be trade offs regarding permit use for different purposes (for example, using the car versus switching the central heating down), which could be an important area for future research particularly given the political interest regarding personal domestic tradable quotas in the UK (Roberts and Thumin, 2006).

Following the open question, respondents were asked to re-rate their acceptability of the TCP scheme using the same 7 point bipolar scale as used previously (see section 7.1 and appendix 4), based on the assumption that their suggested changes were implemented. The results are shown in table 7.9.

Table 7.9 Acceptability ratings for the TCP scheme: pre and post amendment

	Original	Revised
Personal	1.14 (1.59)	1.60 (1.52)
Social	- 0.31 (1.45)	- 0.28 (1.83)

The revised personal ratings have improved slightly in comparison to the original ratings as displayed in table 7.1, with very little change in the social ratings. This suggests that the issues displayed in table 7.7 were largely what people thought could make the TCP scheme work better from a personal perspective rather than making it much more acceptable across society.

7.7 Conclusions and policy implications

The majority of respondents rated both the TCP scheme and FPI as acceptable. In terms of the TCP scheme, the benefits received the necessity to reduce carbon emissions and fairness were the most important reasons for accepting the policy. In relation to the FPI, the main reasons given were the necessity of the scheme with respondents feeling that 'something needs to be done'. This was also found by Jones (2005) and Stradling *et al* (2001). For those rating the policies as unacceptable, complexity of the TCP scheme and unfairness were the most commonly stated reasons. For the FPI, costs and unfairness were the most commonly stated reasons. The Logit analysis further highlighted these results, where personal costs and benefits and fairness were the main predictors of acceptability of the TCP scheme and fairness was the main predictor of acceptability of the FPI. These outcomes are in common with other research findings (Jakobsson *et al.,* 2000; Fujii *et al.,* 2004; Eriksson *et al.,* 2006; Bonsall *et al.,* 2007).

The results collectively reveal fairness and benefits to be very important in terms of acceptability ratings. A key benefit of the TCP scheme is that fairness can be designed into the policy through the permit allocation and possibly placing limits on accounts to avoid stock piling and increasing permit prices unnecessarily. In addition, as recognised by many respondents, there is a limit on carbon availability regardless of willingness to pay. The FPI however is more problematic in terms of increasing fairness – there is no free allocation and no limit on consumption therefore willingness to pay is a more prominent issue in terms of inequities and distribution of impacts. It could be possible to redistribute revenue in order to reduce some of the inequities. This is possibly an important area for future research in terms of comparing the TCP scheme with a FPI that includes a set amount of revenue redistribution. Chapter 6 revealed that the uneven impacts of the FPI across society was one of main reasons for rating the policy as unfair, thus the results could be very different if the FPI was made to be more fair, for example the acceptability of the FPI could increase given that fairness was revealed as the most important predictor of acceptability.

The majority of respondents considered the TCP scheme to be more acceptable than the FPI because it was considered more effective at achieving the carbon reduction targets. Hence, the results indicate that respondents were more willing to accept a policy with a greater level of certainty in terms of effectiveness. Increasing the effectiveness of the FPI implies further price increases which could subsequently require a large amount of revenue redistribution to even out inequities. In turn this could reduce acceptability levels given that monetary costs were the most commonly stated reason for rating the FPI as unacceptable. It therefore appears necessary to convince the public firstly that the fuel price increase is necessary and secondly that it would deliver substantial benefits. Recognisably, the TCP scheme has potential issues in terms of feasibility, complexity and financial costs, however such issues are arguably more resolvable than those related to the FPI.

Chapter 8

Research conclusions, policy implications and future directions

This research set out to explore the feasibility of significantly reducing carbon emissions from personal land based transport through the use of a personal carbon trading scheme. This chapter lists the research objectives and details the crucial aspects of their achievement, followed by the key findings from each chapter. The policy implications of the findings are then discussed followed by suggested areas for future research.

8.1 Research aims and objectives

The policy design, ability to achieve the emissions targets and public response were identified as key research areas in terms of exploring the feasibility of significantly reducing carbon emissions from personal land based transport through the use of a personal carbon trading scheme. Hence, the research objectives were to:

1. Fully design a working personal carbon trading scheme for land based transport including estimated financial costs.
2. Explore behavioural response to a personal carbon trading scheme.
3. Explore public attitudes to a personal carbon trading scheme.

All of the research aims and objectives were satisfied. In order to satisfy the first objective, an extensive review of the literature regarding the design and workings of a TP scheme was undertaken. The literature review revealed a lack of detail in the policy outlines contained within the literature. Hence, in order to explore response to a TP scheme, it was imperative to fully design a working policy. This was a considerable element of the research. The UK governments aim to achieve a 60% reduction of carbon emissions by 2050 was adopted as the emissions target for the Tradable Carbon Permit scheme. A substantial part of the design involved setting out the pathway to achieving a 60% reduction. A linear approach was adopted where the same percentage reduction was applied each year. However, it could be possible to set lower reductions initially and gradually increase as more options for reducing carbon consumption become available. This is possibly an area of debate in terms of which method is most appropriate as it could have strong implications on attaining the target. The permit allocation method is also a changeable aspect of the scheme as there are several options available. For the purpose of this research, an equal per capita permit allocation was selected in recognition of being the most equitable approach, as also identified by the literature review.

From the literature review, fuel price increases were identified as having the potential to achieve the same emissions target as the TCP scheme. Hence, a fuel price increase (FPI) was also designed using the same emissions target as used for the TCP scheme. Conventional elasticities of fuel demand were used in order to derive fuel prices and subsequent carbon reductions. Including the FPI served to identify key differences between the policies in terms of behavioural response, attitudes and effectiveness in relation to how successful each policy was in delivering their respective carbon reduction targets.

Bespoke software was used to record behavioural response. Given the need for interaction with respondents, face to face interviews with individuals were conducted to explore in detail key issues relating to behavioural response, impacts on lifestyle, costs and benefits, fairness, perceived effectiveness and acceptability. In order to obtain comparative responses, the same set of questions was asked in relation to each policy. The low carbon software was designed to include a separate screen for each policy. For both policies, current carbon consumption was shown on the screen. For the TCP scheme, the weekly free allocation of carbon permits was shown. The software served to explain the TCP scheme in terms of how it would work and to illustrate the free permit allocation in relation to current carbon consumption. Following the pre-pilot study, it was decided that estimated permit and fuel prices should be included in the low carbon software and displayed to respondents on-screen next to the corresponding carbon consumption. It was therefore necessary to fully estimate financial costs of the TCP scheme, which was designed to be fully funded through permit revenue. Whilst this process was not originally perceived and hence did not have a time allocation, it was considered very important to provide respondents with an indication of monetary costs particularly as this could form the basis of response and subsequent impacts. A consequence of including estimated permit prices in the TCP scheme and refining the survey implementation was a smaller sample than planned - reducing from 90 interviews to 60.

8.2 Key findings

8.2.1 Design of the TCP scheme

Currently, the TCP scheme developed in this research is the most detailed available in terms of estimated financial costs and revenue generation, estimated permit price, scheme implementation including technology used, the amount of carbon available each year (the annual carbon budget), quantifying the emissions target and relative annual percentage reductions in the carbon budget, and the amount of free carbon permits each person would receive in terms of, for example, carbon per week. Moreover, it is the first personal carbon trading scheme that has been designed in enough detail to allow a comprehensive measurement of public response. Designing the TCP scheme was a crucial part of the research and constitutes one of the main aspects of originality.

8.2.2 Survey design and methodology

The survey was the first to measure behavioural response to a personal carbon trading scheme and to interactively show respondents their free allocation of carbon permits in relation to their current consumption of carbon. In particular, it is the first piece of work to record comparative responses to a personal carbon trading scheme and a fuel price increase, with both policies including estimated spending on fuel and permits. As a result of recording behavioural response through the low carbon software, this is the first study to indicate the impact of behavioural response in relation to the carbon reduction target for the TCP scheme. Hence, in terms of survey design and implementation, the use of the low carbon software to interactively illustrate travel data and resultant carbon emissions clearly demonstrates innovation and originality.

The permit prices used in the low carbon software were fixed prices based on the revenue required from permit sales in order to fully fund the TCP scheme. The low carbon software did not provide an indication of permit availability or estimate permit prices sold on an open market. This could be an important area of development in terms of providing respondents with a more realistic idea of how the scheme could work on a day to day basis and hence making the responses more realistic.

The combination of qualitative and quantitative data collected during the interviews provided a unique insight into public attitudes towards a personal carbon trading scheme which could provide a useful reference point for future research. In addition, the data provided a first set of comparative empirical findings, which undoubtedly contribute to what is emerging as a key political debate and topic of investigation in terms of taxing versus trading.

For the main survey, 60 people were interviewed. The majority of respondents were earning above UK average incomes and consuming an above UK average amount of carbon for personal transport use. A measurement of environmental concern revealed that on average respondents were highly concerned for the environment. Hence, whilst the results are illuminating, the sample size and characteristics should be considered. In addition, it is recognised that the sample size could have constrained the potential of the quantitative modelling work conducted on fairness and acceptability. However, whilst the sample is not representative, a wide and varied range of responses were collected as illustrated in the results chapters which are summarised in the following sections.

8.2.3 Behavioural response

The response to the TCP scheme resulted in an overachievement of the carbon reduction targets. Conversely, the response to the FPI resulted in a failure to achieve the carbon reduction target in any time period despite higher fuel prices relative to the TCP scheme. The FPI was closest to achieving its carbon reduction target in 2030 in response to a 61% price increase.

In total, just over a third of the sample altered their behaviour. A large number of the respondents who did not make any changes were consuming within their free permit allocation and could thus continue current behaviour without any additional monetary costs in relation to the TCP scheme. A number of respondents believed that their current circumstances prevented a reduction in car use and were thus unwilling to change their behaviour and instead would rather pay the increased fuel price and buy additional permits despite the risk regarding availability. A correlation analysis revealed that for the FPI, behavioural response and carbon consumption were significantly and positively related. For the TCP scheme, income, level of impacts on lifestyle and carbon consumption were significantly and positively related to behavioural response. Further exploration revealed that, for the TCP scheme, the above average income earners achieved the greatest reduction in carbon consumption, whereas the average income earners achieved the greatest reduction in response to the FPI.

8.2.4 Impacts on lifestyle, costs and benefits, fairness and perceived effectiveness

The perceived level of impacts on lifestyle were very similar for both policies despite a larger behavioural response in relation to the TCP scheme. Whilst the majority of respondents considered the impacts arising from the TCP scheme to be positive, conversely the majority of respondents considered the impacts arising from the FPI to be negative. This was largely due to the perceived response of others – it was believed that people would have to change in response to the TCP scheme and hence also be disadvantaged, whereas the FPI provided an option to continue current behaviour which was considered to be the most likely public response. Such perceptions largely underpinned the perceived level of costs and/or benefits received. For the TCP scheme, a larger number of respondents perceived benefits, such as reduced levels of air pollution and traffic congestion rather than costs, such as inconvenience and monetary penalties, whereas conversely a larger number of respondents perceived costs rather than benefits resulting from the FPI.

Both policies were considered to be fair by the majority of respondents, however the TCP scheme received higher average ratings than the FPI, which was predicted in the research hypotheses. The equal per capita basis of the free permit allocation was the most commonly stated reason for rating the TCP scheme as fair. In relation to the FPI, the most commonly stated reasons were regarding the necessity of the policy in terms of climate change and the belief that fuel should be more expensive in recognition of the negative environmental impacts. The most commonly stated reasons for considering the TCP scheme to be unfair were the uneven distribution of impacts across society and potential illegal activities in terms of fraudulent permit markets. In relation to the FPI, the uneven distribution of impacts was by far the most commonly stated reason for rating the policy as unfair.

In recognition of the limit on carbon availability, the majority of respondents rated the TCP scheme to be highly effective at achieving the carbon reduction targets, thus providing multiple benefits and making avoidance behaviour largely improbable. In addition, a number of respondents felt that the policy could not be ignored and the purpose was made obvious through the limit on carbon availability and free permit allocation, which was thought to encourage further carbon reductions by increasing awareness of environmental issues. Conversely, the FPI was rated as much less effective by the majority of respondents, with the common belief that people would mostly absorb the increased costs and continue current behaviour.

8.2.5 Acceptability

The majority of respondents rated both policies as acceptable, more so for the TCP scheme. In addition, a much larger number of respondents considered the TCP scheme to be acceptable. However, both policies received higher than expected acceptability ratings which could be largely explained by the sample characteristics as other research has shown higher acceptance of transport pricing policies amongst highly educated respondents (Rienstra *et al.,* 1999).

In terms of the TCP scheme, the perceived benefits, the necessity to reduce carbon emissions and fairness were the most important reasons for accepting the policy. In relation to the FPI, the necessity to reduce carbon emissions was the main reason given with respondents feeling that 'something needs to be done', which was also found in other surveys (Jones, 2005; Stradling *et al.*, 2001). Within the research hypotheses, it was predicted that the TCP scheme would be accepted by the majority of respondents due to the feeling that 'something needs to be done'. In addition, the perceived benefits and the feeling that fuel should be more expensive in order to more accurately reflect the associated environmental costs were amongst the most commonly stated reasons. For those rating the policies as unacceptable, complexity of the TCP scheme and unfairness were the most commonly stated reasons. For the FPI, costs and unfairness were the most commonly stated reasons. An ordered Logit model further highlighted these results, where personal costs and benefits and fairness were the main predictors of acceptability of the TCP scheme and fairness was the main predictor of acceptability of the FPI. These outcomes are in common with other research findings (Jakobsson *et al.,* 2000; Fujii *et al.,* 2004; Eriksson *et al.,* 2006; Bonsall *et al.,* 2007) and are also logical in terms of issues discussed above in relation to the costs and benefits, fairness and perceived effectiveness.

In terms of making the TCP scheme more acceptable, varying the permit allocation to reflect individuals' carbon needs was the most commonly stated response. The majority of suggestions were related to the design of the scheme, for example, regarding the trade of permits between individuals, permit banking, the use of a price premium and the inclusion of all domestic energy.

The majority of the sample supported the inclusion of air transport for both policies, more so for the TCP scheme. Interestingly, the number of people supporting the inclusion of air transport in the TCP scheme was slightly higher than the number of people considering the inclusion of road transport in the TCP scheme as acceptable. The difference was even more apparent for the FPI.

8.3 Policy implications

There was a clear difference in attitudes towards the policies - respondents were much more positive about the TCP scheme than the FPI. In addition, the average ratings revealed the TCP scheme to be more favourable in every aspect. Hence, whilst fuel price increases and tradable permit schemes are very similar in theory, the public response revealed stark differences in terms of how the policies were perceived. The difference in attitudes appeared to be largely a result of perceived effectiveness of the policies - many respondents were unconvinced that the FPI would deliver substantial benefits, with the belief that the majority of individuals would continue their current car use. In contrast, the TCP scheme was viewed as largely unavoidable and hence would deliver benefits. Thus, respondents would rather support a policy where the ability to achieve the carbon reductions was more certain. The difference in perceptions between the policies could have major impacts on response – it appeared that people were more willing to change their behaviour in response to the TCP scheme as they thought that other people would also be changing their behaviour given the limit on carbon availability. The TCP scheme therefore offered people a level of reassurance that their efforts to reduce carbon emissions would not be in vain. The FPI did not have this effect, with the majority of respondents feeling that the lack of a limit on availability could result in a much lower response. Hence, the perceived response of others appeared to be very important in influencing the decision to change behaviour and particularly whether attitudes towards the policy would be positive or negative.

The limit on carbon availability and subsequent uncertainty were crucial in prompting the behavioural response to the TCP scheme. Hence, the TCP scheme would benefit from risk averse behaviour in that people try to avoid a situation where they are unable to obtain permits by reducing their consumption. The mechanism for stimulating behavioural change for the FPI is very different in that it relies solely on willingness to pay. Increasing the effectiveness of the FPI implies further price increases. However, this could reduce public acceptability in addition to inevitably raising issues regarding inequities and employing an appropriate revenue redistribution in terms of achieving a fair method without jeopardising the attainment of the carbon reduction targets but whilst also maintaining significant revenues to improve public transport. Whilst the TCP scheme would inherently cause inequities, the provision of a free permit allocation implies fewer inequities in comparison to the FPI and is therefore arguably less of an issue. Interestingly, several respondents suggested that the FPI should be accompanied by tax cuts elsewhere, whereas this was not mentioned in relation to the TCP scheme.

During the survey it was suggested that the TCP scheme could make people aware of their environmental impacts resulting from all aspects of their lifestyle and ways to reduce them, therefore further increasing policy effectiveness and subsidiary benefits through the uptake of environmentally astute behaviour (Starkey and Anderson, 2005). This impact was not suggested for the FPI, which could possibly be a result of negative preconceptions in regard to past uses of fuel taxation to raise revenue rather than to improve the environment. Hence it is possible that perceptions of the FPI could be changed by introducing it as a carbon tax, which would perhaps help to remind people of the policy aim and also stimulate environmentally astute behaviour. It should be noted that the difference in perceptions between the policies could result from familiarity in that the fuel tax concept is well known whereas the concept of the TCP scheme is relatively new and unknown. Hence, with increased familiarity it is possible that attitudes and response towards the TCP scheme would change and could become more similar to those relating to the FPI. However, the possibility of attitudes changing over time could be hinged to a greater extent on the ability of the TCP scheme to achieve its carbon reduction target given that effectiveness was identified as the basis for differing attitudes between the policies. Thus, regardless to familiarity with the concept, providing that the TCP scheme is effective, attitudes would not be expected to vary greatly over time. Hence, it is highly possible that attitudes relating to the TCP scheme are related more to the core design in terms of the limit on carbon availability rather than familiarity with the concept.

It is possible that a full exploration of attitudes including Perceived Behavioural Control, personal norms and intentions would be very useful in addition to identifying actual barriers to change. Behaviours could then be targeted through both information campaigns and practical solutions. In addition, it could be possible to vary permit allocations to account for actual barriers to change. Whilst the equal per capita allocation is perceived to be most equitable in the literature (Starkey and Anderson, 2005; Hillman and Fawcett, 2004; Fleming, 2007) and was the most commonly stated reason for considering the TCP scheme to be fair, a number of respondents suggested that the permit allocations should be varied to take account of varying demands, for example those with children. Whilst there is a danger that varying allocations could be viewed as unfair, it would be a similar principle to current allocations such as child benefit payments which could also be considered as inequitable to those individuals without children. However, there is very little public debate about this subject.

It appears that a substantial amount of effort would be required in terms of providing options for people to enable behavioural change. For example, many respondents stated that they would work at home but were constrained by their employers. Hence, the issues raised suggest that supportive measures to enable such behaviours should be included with the introduction of the TCP scheme. Many respondents that did not change their behaviour considered public transport as an inadequate alternative to car, particularly for leisure trips. Whilst it would be imperative to improve services, it is unrealistic to expect a public transport service to offer the same level of speed, reliability and comfort as private transport. It is possible that attitudes and social norms regarding public transport could be influenced by information campaigns and would become much more positive as the scheme progressed.

Recent work by the IPCC (2007) indicates that urgent action is required regarding climate change and urges political leaders to rapidly implement means of attaining significant carbon reductions. Whilst both policies were considered to be acceptable by the majority of respondents, in terms of the urgency of climate change it is arguably more important to select the policy which is most capable and certain of achieving significant carbon reductions. Hence, whilst important, acceptability should not be the focal point in terms of decision making and policy implementation. One of the key findings and perhaps the most important policy implication is the differing ability to achieve the carbon reduction targets – the TCP scheme was 110% effective whilst the FPI was only 80% effective. However, it should be noted that the behavioural response was not measured past 2030. Whilst the results show that the FPI became more effective in the long term, in order to achieve the overall carbon reduction target by 2050 the FPI would need to substantially overachieve intermediate targets leading up to 2050 which is somewhat unrealistic. In terms of attaining legally binding carbon reduction targets, the results suggest that the TCP scheme would provide more certainty than the FPI. Moreover, the results raise questions regarding the suitability of the FPI as a sole measure to achieve significant and imperative carbon reductions. As noted by respondents, 'something needs to be done', and it is highly possible that a TP scheme could play a crucial role.

8.4 Recommendations for further research

This research has highlighted several key areas for future research that would need to be addressed before the TCP scheme can be seriously considered as a climate change policy.

This research suggested that permit revenue raised through selling 50% of the annual carbon budget could be used to fully fund the scheme, including the replacement of lost fuel tax revenue. The resultant permit prices were not excessive, as mentioned by a number of respondents. However, it is possible that the scheme would be less acceptable if initial (fixed) permit prices were higher than those estimated in the survey. Hence, it is imperative to improve the accuracy of the estimated costs by conducting a full cost-benefit analysis. In addition, an indication of the variation in permit price under open market conditions would be useful in making the survey more realistic and for measuring the impact on public response.

A number of respondents suggested that the TCP scheme would be more personally acceptable with the use of varied permit allocations rather than using an equal per capita approach. In addition, it could be possible to better manage the demand for carbon by varying permit allocations based on socioeconomic characteristics and/or actual barriers to change. In recognition that it would not be possible to please everyone, the allocation should perhaps reflect demand to an extent. Inevitably there are implications of giving different permit allocations in terms of efficiency (having unused permits in the system), behavioural response, social impacts and public acceptability. Hence, the method of permit allocation could be a key aspect of the TCP scheme and should therefore be fully investigated. This could possibly be achieved through a stated preference experiment where participants are presented with the relative attributes of each allocation and subsequently select which permit allocation they prefer, which could later be investigated in relation to their personal socioeconomic characteristics, carbon consumption and attitudes. This method could provide an indication of which type of permit allocation would be most preferred by which 'type' of person. This data could then be grossed up to a national level and subsequently form the basis of allocation.

One of the potential problems identified in the SP experiment conducted as part of this research was the ability to include the free permit allocation as an independent variable in a way that respondents could fully understand. Hence it would be useful to identify a means of including the allocation in a form, for example in monetary value, carbon/litres of fuel equivalence, which can be easily understood by respondents to the level where it can be used in the decision regarding preference between different options.

The sample size and characteristics must be considered when interpreting the research findings. Hence, one of the most crucial areas for further research would be to observe any key differences in response amongst a large and nationally representative sample. As a result of the free permit allocation, the response to the TCP scheme would be less dependant upon income then the

FPI and hence would not be expected to differ significantly amongst a lower income sample. However, it is possible that the response would differ amongst a sample with lower levels of concern for the environment. If so, it could be possible to increase response by increasing awareness of environmental issues prior to policy implementation. In addition, it could be useful to categorise responses through attitudes and beliefs including perceived behavioural control in recognition that socioeconomic characteristics do not always fully explain and/or predict behaviour. Since the research began the concept of carbon trading and issues surrounding climate change have appeared in the media on several occasions, hence it should be recognised that attitudes and/or awareness of the topic could have altered for this reason. However, the increased familiarity of personal carbon trading amongst the public could aid future research in that it may be possible to conduct a largely quantitative style investigation amongst a larger sample within a similar timeframe.

During the interviews several respondents mentioned the need to include all personal energy use within the TCP scheme. Chapter 2 reviewed suggestions for a national personal carbon trading scheme to include all personal energy use. It is inevitable that all domestic energy would require regulation in order to achieve a 60% carbon reduction by 2050. Hence, there are several interesting and necessary areas for investigation regarding the impacts (in terms of effectiveness), public attitudes (including acceptability), and response (including trade offs between different energy use), towards a TCP scheme if applied to all domestic energy consumption.

References

Adam, D. and Batty, D (2006) *Miliband unveils carbon swipe-card plan.* Guardian Unlimited, 19th July 2006.

Ajzen, I. (1991) The theory of planned behaviour. Organisational Behaviour and Human Decision Processes 50, pp. 179-211.

Anable, J (2005) 'Complacent car addicts' or 'Aspiring environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy,* 12 pp.65-78.

Anable J. and Bristow A.L. (2007) Transport and Climate Change: Supporting document to the CfIT report. September 2007. Report prepared for the Climate Change Working Group of the Commission for Integrated Transport. http://www.cfit.gov.uk/docs/2007/climatechange/index.htm

Association des Constructeurs Europeens d'Automobiles/European Community (1998) (ACEA/EC) CO2 emissions from cars: the EU implementing the Kyoto Protocol.

Bonsall, P. Shires, J. Maule, J. Matthews, B. and Beale, J (2007) Responses to complex pricing signals: Theory, evidence and implications for road pricing. Transportation Research Part A 41 pp.672-683.

Bottrill, C (2006) *Personal Carbon Trading: An exploratory research and policy workshop.* Workshop summary report. UK Energy Research Centre, London.

Bows, A. Mander, S. Starkey, R. Bleda, M. and Anderson, K (2006) *Living within a carbon budget.* Report for Friends of the Earth and The Co-operative Bank, July 2006. Available at:
http://www.foe.co.uk/resource/reports/living_carbon_budget.pdf

Brand, C. Preston, J and Boardman, B (2006) Counting your carbon: The development and deployment of integrated travel emissions profiles.

Bristow, A. Pridmore, A. Tight, M. and May, A. (2004) How can we reduce Carbon emissions from transport? Tyndall Centre Technical Report 15.

Button, K. J. and Verhoef, E. T. (2000) Road pricing, traffic congestion and the environment. Edward Elgar Publishing Limited, Cheltenham, UK.

Commission for Integrated Transport (CfIT) (2002) *The CfIT report: Public attitudes to transport in England.* A survey carried out by MORI for CfIT. Available at:
http://www.cfit.gov.uk/docs/2002/mori2002/mori2002/02.htm

Committee on the Medical Effects of Air Pollutants (COMEAP) (1998) *The quantification of the effects of air pollution on health in the UK.*

Cook, M. (2005) A practical road user charging system for the UK. White Paper.

Coolican, H. (1999) Research methods and statistics in psychology. Third edition. Hodder and Stoughton, London.

Crals, E. Keppens, M. and Vereeck, L. (2003) Tradable Fuel Permits: Towards a sustainable transport system. In Wulfhorst, J. D. and Haugestad, A. K. Future as fairness: Ecological justice and global citizenship.

Cramton, P. and Kerr, S. (2002) Tradeable carbon permits auctions: How and why to auction not grandfather. *Energy Policy*, 30, pp.333-345.

Dales, J. G. (1968) Land, water, and ownership. *Canadian Journal of Economics*, 1, pp.791-804.

Dargay, J (2004) The effect of prices and income in car travel in the UK. Presented at the WCTR, Istanbul July 2004.

Department of the Environment, Food and Rural Affairs (2006b) Climate Change: The UK Program. March 2006. CM 6764.

Department for Environment, Food and Rural Affairs (DEFRA) (2006a) e-Digest of Environmetnal statistics.
Available at
http://www.defra.gov.uk/environment/statistics/globatmos/gagccukem.htm

Department of the Environment, Food and Rural Affairs (2006c) Speech by the Rt Hon David Miliband MP - "The great stink: towards an environmental contract " at the Audit Commission annual lecture, Wednesday, 19 July 2006. Available at: http://www.defra.gov.uk/corporate/ministers/speeches/david-miliband/dm060719.htm

Department of the Environment, Food and Rural Affairs (DEFRA) (2007) *Draft Climate Change Bill.* Consultation document, March 2007. The Stationery Office, London.

Department of the Environment, Food and Rural Affairs/Department for Transport (DEFRA/DfT) (2007) Consultation on the Commission's proposal to include aviation in the European Union emissions trading scheme. March 2007.

Department for Transport (DfT) (2003) *Aviation White Paper: The future of air transport.* London.

Department for Transport (DfT) (2005) *Transport Statistics Great Britain: 2004 Edition.* London.

Department for Transport (DfT) (2006a) *Transport Statistics Great Britain: 2005 Edition.* London.

Department for Transport (DfT) (2006b) *Transport Trends: 2005 Edition.* London.

Department for Transport (DfT) (2006c) Attitudes to climate change and the impact of transport. Available at: http://www.dft.gov.uk/162259/162469/221412/221513/222693/AttToCCReport.pdf

Department for Transport (DfT) (2007) Road transport and the EU Emissions Trading Scheme. London.

Department of Health (DoH) (1998) Quantification of the effects of air pollution on health in the UK. London.

Department of Health/Health Protection Agency (DoH/HPA) (2007) Health effects of climate change in the UK: an update of the Department of Health report 2001/2002. Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_080702

Department of Trade and Industry (DTI) (2003) *Our Energy Future Creating a Low Carbon Economy*. Cm5761, The Stationery Office.

Department of Trade and Industry (DTI) (2007) *Meeting the energy challenge.* Cm 7124, The Stationery Office. May 2007.

Directive 2003/87/EC of the European Parliament and of the Council (2003) Establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

Dobes, L. (1997) Kyoto: tradable greenhouse emission permits in the transport sector. *Transport Reviews*, Volume 19, Number 1, pp.81-97.

Dresner, S and Ekins, P (2004) *The distributional impacts of economic instruments to limit greenhouse gas emissions from transport.* PSI research discussion paper 19.

Dresner, S. Jackson, T. and Gilbert, N (2006) History and social responses to environmental tax reform in the United Kingdom. *Energy Policy* 34 pp.930-939.

Dunlap, R. E. Van Liere, K. D. Mertig, A. G. and Emmet Jones, R. (2000) Measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of Social Issues*, 56 (3) pp.425-442.

Elliot, L. and Wintour, P (2007) Bush agrees to CO2 cut, with strings attached. G8 special report. Guardian, 8th June 2007.

Eriksson, L. Garvill, J. and Nordlund, A.M. (2006) Acceptability of travel demand management measures: The importance of problem awareness, personal norm, freedom and fairness. Journal of environmental psychology 26 pp. 15-26.

European Commission (EC) (2003) Greenhouse gas emissions trading and climatic change.
Available at http://europa.eu.int/scadplus/leg/en/lvb/128109.htm

European Commission (EC) (2006a) Emissions trading: Commission decides on first set of national allocation plans for the 2008-2012 trading period.
Available at:
http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/1650&format=HTML&aged=0&language=EN&guiLanguage=en

European Commission (EC) (2006b) Building a global carbon market - Report pursuant to Article 30 of Directive 2003/87/EC. Brussels, 13.11.2006 COM(2006)676 final.
Available at:
http://ec.europa.eu/environment/climat/emission/pdf/com2006_676final_en.pdf

Fawcett , T. (2005) Carbon rationing and personal energy use. *Energy and Environment*, 15 (6) pp. 1067 - 1083.

Fleming, D. (1996) Stopping the traffic. *Country Life*, Volume 140 (19) pp. 62-65.

Fleming (2007) *Energy and the common purpose. Descending the energy staircase with Tradable Energy Quotas (TEQs).* The lean economy connection, London.

Fransson, N. and Garling, T. (1999) Environmental concern: Conceptual definitions, measurement methods, and research findings. *Journal of Environmental Psychology*. 19, pp.369-382.

Fujji, S. Garling, T. Jakobsson, C. and Rong-Chang Jou. (2004) A cross-country study of fairness and infringement on freedom as determinants of car owners' acceptance of road pricing. *Transportation*, 31, pp.285-295.

Glaister, S. and Graham, D. (2000) *The effect of fuel prices on motorists*. Imperial college of Science, Technology and Medicine, London. AA Motoring Policy.

Graham, D. and Glaister, S. (2002) *Review of income and price elasticities of demand for road traffic.* Centre for Transport Studies. Imperial College of Science, Technology and Medicine.

Grayling, T. Gibbs, T. and Castle. B (2006) *Tailpipe trading: how to include road transport in the EU Emissions Trading Scheme (EU ETS)*. Institute for Public Policy Research. LowCVP 'Low Carbon Road Transport Challenge'.

Groot, J. and Steg, L (2006) The role of value orientations in evaluating quality of life consequences of a transport pricing policy. Transportation Research D (11) pp.160-165.

Harrison, D. (1999) Tradable permits for air pollution control: the US experience. In: OECD (1999) Implementing domestic tradable permits for environmental protection. Paris. pp. 23-50.

Hillman, M and Fawcett, T (2004) *How we can save the planet.* Penguin, London.

HM Government (2004) Preparing for emergencies.
Available at www.preparingforemergencies.gov.uk/

Home Office (2004) Identity cards.
Available at www.homeoffice.gov.uk/comrace/identitycards/index.html

Intergovernmental Panel on Climate Change (IPCC) (2007) Summary for Policymakers. In Climate change 2007: Mitigation. Contribution of Working group III to the Fourth Assessment Report of the InterGovernmental Panel on Climate Change [B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, L. A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jaensirisak, S. May, A. D. and Wardman, M. (2003) *Acceptability of road user charging: The influence of selfish and social perspectives*. In: Schade, J. and Schlag, B. (2003) Acceptability of transport pricing strategies. Elsevier Ltd, Oxford.

Jaensirisak, S. May, A. D. and Wardman, M. (2005) Explaining variations in public acceptability of road pricing schemes. Journal of transport economics and policy. Volume 39, part 2. pp 127-153.

Jakobsson, C. Fujii, S. and Garling, T. (2000) Determinants of private car users' acceptance of road pricing. *Transport Policy* 7 153-158.

Jakobsson, C. Fujii, S. and Garling, T. (2002) Effects of economic disincentives on private car use. *Transportation* 29 pp.349-370.

Jensen, M (1999) Passion and heart in transport - a sociological analysis on transport behaviour. *Transport Policy* (6) pp.19-33.

Jones, P. (1995) *Road pricing: the public viewpoint*. In: Johansson, B. and Mattsson, L. G. (1998) Road pricing: Theory, empirical assessment and policy. Third edition. Kluwer academic publishers. Massachusetts, USA.

Jones, P. (2003) Acceptability of road user charging: meeting the challenge. In: Schade, J. and Schlag, B. (2003) Acceptability of transport pricing strategies. Elsevier Ltd, Oxford.

Keay-Bright, S. and Fawcett, T. (2005) *Taxing and Trading: Debating options for Carbon reduction.* UK Energy Research Centre Meeting Report.

Keppens, M. and Vereeck, L. (2003) *The design and effects of a tradable fuel permit system.* Association for European Transport. Presented at the European Transport Conference, October 2003.

Kingham, S. Dickinson, J. and Copsey, S. (2001) Travelling to work: will people move out of their cars? *Transport Policy*. Volume 8, Number 2, pp.151-161

Kroon (2006) Speed Limits and eco-driving: cleaner air though speed limits and eco-driving. Presentation to IAPSC Conference, London 21st June 2006.

Loukopoulos, P. Jakobsson, C. Garling, T. Meland, S. and Fujii, S (2006) Understanding the process of adaptation to car use reduction goals. *Transportation Research Part F* (9) pp.115-127.

Lyons, G. Chatterjee, K. Beecroft, M. and Marsden, G. (2002) Determinants of travel demand-exploring the future of society and lifestyles in the UK. *Transport Policy,* 9, pp.17-27.

May, A. D. (1992) Road pricing: an international perspective. *Transportation*. 19 (4), pp. 313-33.

Meyer, A. (2000) *Contraction and Convergence: the global solution to climate change*. Green books, Totnes.

MORI (2007) *Public attitudes towards aviation and climate change*.
Available at: http://www.cfit.gov.uk/docs/2007/climatechange/index.htm

Michaelis P and Zerle P. (2006) From ACEA's Voluntary Agreement to an Emission Trading Scheme for New Passenger Cars. Journal of Environmental Planning and Management 49(3) pp435-453.

National Atmospheric Emissions Inventory (NAEI) (2005) Data warehouse
Available at: http://www.naei.org.uk/data_warehouse.php

Norton, A. and Leaman, J. (2004) *The day after tomorrow: Public opinion on climate change.* MORI Social Research Institute.
Available at: http://www.ipsos-mori.com/publications//jl/the-day-after-tomorrow.pdf

Oberholzer-Gee, F. and Weck-Hannemann, H. (2002) Pricing road use: politico-economic and fairness considerations. Transportation Research. Part D, 7, pp.357-371.

Office of National Statistics (ONS) (2001) Census 2001 United Kingdom. Available at: http://www.statistics.gov.uk/CCI/nugget.asp?ID=950&Pos=1&ColRank=2&Rank=672

Organisation for Economic Co-operation and Development (OECD) (1999) Implementing domestic tradable permits for environmental protection. Paris.

Organisation for Economic Co-operation and Development (OECD) (2002) Implementing domestic tradable permits: recent developments and future challenges. Paris.

Potter, S. Enoch, M and Fergusson, M (2001) Fuel taxes and beyond: UK transport and climate change.

Raje, F. (2003) The impact of transport on social exclusion processes with specific emphasis on road user charging. *Transport Policy* (10) pp.321-338

Raux, C. (2002) *The use of transferable permits in the transport sector*. In: (OECD) (2002) Implementing domestic tradable permits: recent developments and future challenges, pp. 141-183.

Raux, C. (2004) The use of transferable permits in transport policy. *Transportation Research Part D*, 9 (3) 185-1997.

Raux, C. and Marlot, G (2005) A system of tradable CO_2 permits applied to fuel consumption by motorists. *Transport Policy*, 12 (3) 255-265.

Rienstra, S. A. Rietveld, P. and Verhoef, E. T. (1999) The social support for policy measures in passenger transport. A statistical analysis for the Netherlands. *Transportation Research Part D,* 4, pp.181-200.

Rietveld, P. and Verhoef, E.T. (1998) Social feasibility of policies to reduce externalities in transport. In: Button, K. J. and Verhoef, E. T. (2000) Road pricing, traffic congestion and the environment. Edward Elgar Publishing Limited, Cheltenham, UK.

Roberts, S. and Thumin, J (2006) *A rough guide to individual carbon trading.* Centre for sustainable energy. Report to Department for Environment, Food and Rural Affairs.

Robson, C (2002) Real world research. Second edition. Blackwell publishing limited.

Royal Society for Arts (RSA) (2006) 'Carbon' YouGov survey results. Available at:
http://www.rsacarbonlimited.org/uploads/documents/RESULTS%20for%20RSA%20(Carbon)%2002-10-06_21.xls

Schade, J. (2003) European research results on transport pricing acceptability. In: Schade, J. and Schlag, B. (2003) Acceptability of transport pricing strategies. Elsevier Ltd, Oxford.

Schade, J. and Schlag, B. (2003) Acceptability of urban transport pricing strategies. *Transportation Research Part F,* 6, pp. 45-61.

Schlag, B. and Schade, J. (2000) Public acceptability of traffic demand management in Europe. *Traffic Engineering and Control*, 41, pp314-318.

Schlag, B. and Tuebel, U. (1997) Public acceptability of transport pricing. *IATSS Research*, 21, pp134-142.

Shannon, T. Giles-Corti, B. Pikora, T. Bulsara, M. Shilton, T. and Bull, F (2006) Active commuting in a university setting: Assessing commuting habits and potential for modal change. *Transport Policy* (13) pp.240-253.

Small, K.A. and Gomez-Ibanez, J. (2000) Road pricing for congestion management: the transition from theory to policy. In: Button, K. J. and Verhoef, E. T. (2000) Road pricing, traffic congestion and the environment. Edward Elgar Publishing Limited, Cheltenham, UK. pp. 213-247.

Society of Motor Manufacturers and Traders Ltd (SMMT) (2005) CO_2 Emission Service. Available at: http://195.167.170.192/co2search.asp

Starkey, R. and Anderson, K. (2005) *Domestic Tradable Quotas: A policy instrument for reducing greenhouse gas emissions from energy use*. Tyndall Technical Report 39. Tyndall Centre for Climate Change Research.

Steedman, J. (1999) *The case of the UK: Sulphur permit quota switching.* In: OECD (1999) Implementing domestic tradable permits for environmental protection. Paris. pp. 183-195.

Steg, L. (2003) Factors influencing the acceptability and effectiveness of transport pricing. In: Schade, J. and Schlag, B. (2003) Acceptability of transport pricing strategies. Elsevier Ltd, Oxford.

Steg, L (2005) Car use: lust and must. Instrumental, symbolic and affective motives for car use. *Transportation Research A* (39) pp.147-162.

Stern (2006) Stern review on the economics of climate change.

Available at:
http://www.hmtreasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm

Stradling, S.G, Meadows, M.L. and Beatty, S. (2000) Helping drivers out of their cars: integrating transport policy and social psychology for sustainable change. *Transport Policy*. Volume 7, number 3, pp.207-217.

Svendsen, G. T (1999) U.S interest groups prefer emission trading: A new perspective. *Public Choice* 101 pp 109-128.

Swedish Environmental Protection Agency (SEPA) (2006) Dealing with transport emissions: an emissions trading scheme for the transport sector, a viable solution? Report 5550, March 2005.

Tietenberg, T. H. (1985) *Emissions trading: An exercise in reforming pollution policy.* Resources for the future, Washington. D. C.

Tietenberg, T. H. (2000) The tradable permits approach to protecting the commons: What have we learned?

Transport for London (TfL) (2003) Central London Congestion Charging Scheme: Impacts Monitoring-1st Annual Report.
Available at www.tfl.gov.uk/tfl/cc_monitoring.shtml

Transport for London (TfL) (2004) Central London Congestion Charging Scheme: Impacts Monitoring - 2nd Annual Report: April 2004.
Available at www.tfl.gov.uk/tfl/cclondon/cc_monitoring-2nd-report.shtml

Ubbels, B and Verhoef, E (2006) *Behavioural response to road transport pricing "A multidisciplinary perspective"*. Presented at the TRB meeting 2006.

United Nations Framework Convention on Climate Change (UNFCCC) (1992) Kyoto Protocol to the United Nations Framework Convention on Climate Change.

United Nations Environment Programme (UNEP) (2003) *A guide to emissions trading.* Available at www.unep.fr/energy/publications/pdfs/EmissionsTrading-Feb03.pdf

Vehicle Certification Agency (VCA) (2005) Database search
Available at: http://www.vcacarfueldata.org.uk/search/search.asp

Verhoef, E. Nijkamp, P. and Rieveld, P. (1997) Tradeable permits: their potential in the regulation of road transport externalities. *Environment and Planning B: Planning and Design.* Volume 24, pp.527-548.

Viegas, J.M. (2001) Making urban road pricing acceptable and effective: searching for quality and equity in urban mobility. *Transport Policy.* Volume 8, Issue 4, pp.289-294.

Walton, D. Thomas, J. A. and Dravitzki, V. (2004) Commuters concern for the environment and knowledge of the effects of vehicle emissions. *Transportation Research Part D,* 9 335-340.

Watters, H.M and Tight, M.R (2007) Designing an emissions trading scheme suitable for surface transport. February 2007. Report prepared for the Climate Change Working Group of the Commission for Integrated Transport.
Available at: http://www.cfit.gov.uk/docs/2007/climatechange/index.htm

Weigel, R. and Weigel, J. (1978) Environmental concern: The development of a measure. *Environment and Behaviour*, 10 (1) 3-15.

Whittles, M. J. (2003) Urban road pricing: public and political acceptability. Ashgate Publishing Limited. Hants, England.

Zhang, J. Timmermans, H. Borgers, A. and Wang, D (2004) Modeling traveler choice behaviour using the concepts of relative utility and relative interest. *Transportation Research B* (38) pp.215-234.

Appendix 1: TCP scheme – financial costs, carbon budget and permit allocation

Year	Annual % reduction	Carbon budget Kg m	Free carbon budget kg m	Free permit allocation kg /person/ week	Lost fuel tax revenue £ m	TCP financial costs £m	Permit price £/kg carbon	Permit and fuel/kg carbon £
2005	1.34	26165	11351	4.73	231	594	0.05	1.41
2006	2.68	25809	11197	4.66	463	777	0.06	1.43
2007	4.02	25454	11042	4.60	694	1,008	0.08	1.45
2008	5.36	25099	10888	4.54	925	1,239	0.10	1.47
2009	6.7	24743	10734	4.47	1,156	1,470	0.12	1.49
2010	8.04	24388	10580	4.41	1,388	1,702	0.14	1.51
2011	9.38	24032	10426	4.34	1,619	1,933	0.16	1.53
2012	10.72	23677	10272	4.28	1,850	2,164	0.18	1.55
2013	12.06	23322	10117	4.21	2,081	2,396	0.21	1.57
2014	13.4	22966	9963	4.15	2,313	2,627	0.23	1.60
2015	14.74	22611	9809	4.09	2,544	2,858	0.25	1.62
2016	16.08	22256	9655	4.02	2,775	3,089	0.28	1.65
2017	17.42	21900	9501	3.96	3,007	3,321	0.30	1.67
2018	18.76	21545	9347	3.89	3,238	3,552	0.33	1.70
2019	20.1	21189	9192	3.83	3,469	3,783	0.36	1.73
2020	21.44	20834	9038	3.76	3,700	4,014	0.39	1.75
2021	22.78	20479	8884	3.70	3,932	4,246	0.41	1.78
2022	24.12	20123	8859	3.64	4,163	4,477	0.44	1.81
2023	25.46	19768	8576	3.57	4,394	4,708	0.48	1.84
2024	26.8	19413	8422	3.51	4,625	4,940	0.51	1.88
2025	28.14	19057	8267	3.44	4,857	5,171	0.54	1.91
2026	29.48	18702	8113	3.38	5,088	5,402	0.58	1.95
2027	30.82	18347	7959	3.32	5,319	5,633	0.61	1.98
2028	32.16	17991	7805	3.25	5,550	5,865	0.65	2.02
2029	33.5	17636	7651	3.19	5,782	6,096	0.69	2.06
2030	34.84	17280	7497	3.12	6,013	6,327	0.73	2.10
2031	36.18	16925	7342	3.06	6,244	6,558	0.77	2.14
2032	37.52	16570	7188	2.99	6,476	6,790	0.82	2.19
2033	38.86	16214	7034	2.93	6,707	7,021	0.87	2.23
2034	40.2	15859	6880	2.87	6,938	7,252	0.91	2.28
2035	41.54	15504	6726	2.80	7,169	7,483	0.97	2.33
2036	42.88	15148	6572	2.74	7,401	7,715	1.02	2.39
2037	44.22	14793	6417	2.67	7,632	7,946	1.07	2.44
2038	45.56	14437	6263	2.61	7,863	8,177	1.13	2.50
2039	46.9	14082	6109	2.55	8,094	8,409	1.19	2.56
2040	48.24	13727	5955	2.48	8,326	8,640	1.26	2.63
2041	49.58	13371	5801	2.42	8,557	8,871	1.33	2.70
2042	50.92	13016	5647	2.35	8,788	9,102	1.40	2.77
2043	52.26	12661	5492	2.29	9,020	9,334	1.47	2.84

2044	53.6	12305	5338	2.22	9,251	9,565	1.55	2.92
2045	54.94	11950	5184	2.16	9,482	9,796	1.64	3.01
2046	56.28	11595	5030	2.10	9,713	10,027	1.73	3.10
2047	57.62	11239	4876	2.03	9,945	10,259	1.83	3.19
2048	58.96	10884	4722	1.97	10,176	10,490	1.93	3.30
2049	60.3	10528	4567	1.90	10,407	10,721	2.04	3.41
2050	61.64	10173	4413	1.84	10,638	10,953	2.15	3.52

Appendix 2: FPI – elasticities, demand reductions and fuel prices.

Year	Elasticity applied	% price increase	% reduction in fuel demand	Fuel price pence/litre	Price increase pence/litre	Price pence/ kg carbon
2005	-0.25	1	0.25	86	1	136
2006	-0.25	1	0.25	87	2	137
2007	-0.25	1	0.25	88	3	138
2008	-0.25	1	0.25	88	3	140
2009	-0.25	1	0.25	89	4	141
2010	-0.3	1.5	0.45	91	6	143
2011	-0.35	1.5	0.525	92	7	145
2012	-0.4	1.5	0.6	93	8	148
2013	-0.45	1.5	0.675	95	10	150
2014	-0.5	1.5	0.75	96	11	152
2015	-0.55	1.5	0.825	98	13	154
2016	-0.6	1.5	0.9	99	14	157
2017	-0.65	1.5	0.975	101	16	159
2018	-0.7	2	1.4	103	18	162
2019	-0.7	2	1.4	105	20	165
2020	-0.7	2	1.4	107	22	169
2021	-0.7	2	1.4	109	24	172
2022	-0.7	2	1.4	111	26	176
2023	-0.7	2.5	1.75	114	29	180
2024	-0.7	2.5	1.75	117	32	184
2025	-0.7	2.5	1.75	120	35	189
2026	-0.7	2.5	1.75	123	38	194
2027	-0.7	2.5	1.75	126	41	199
2028	-0.7	3	2.1	129	44	205
2029	-0.7	3	2.1	133	48	211
2030	-0.7	3	2.1	137	52	217
2031	-0.7	3	2.1	141	56	224
2032	-0.7	3	2.1	146	61	230
2033	-0.7	4	2.8	152	67	239
2034	-0.7	4	2.8	158	73	249
2035	-0.7	4	2.8	164	79	259
2036	-0.7	4	2.8	170	85	269
2037	-0.7	4	2.8	177	92	280
2038	-0.7	4.5	3.15	185	100	293
2039	-0.7	4.5	3.15	194	109	306
2040	-0.7	4.5	3.15	202	117	320
2041	-0.7	4.5	3.15	211	126	334
2042	-0.7	4.5	3.15	221	136	349
2043	-0.7	5	3.5	232	147	367
2044	-0.7	5	3.5	244	159	385
2045	-0.7	5	3.5	256	171	404

2046	-0.7	5	3.5	269	184	424
2047	-0.7	5	3.5	282	197	446
2048	-0.7	5.5	3.85	298	213	470
2049	-0.7	5.5	3.85	314	229	505
2050	-0.7	5.5	3.85	331	246	522

Appendix 3: Example of 7-day travel dairy

Monday

Vehicle 1 make and model:____________________ Fuel type ________ Age_____ year

Journey 1	Journey 2	Journey 3	Journey 4
Mode used ✓ Car Bus Train Cycle Walk Motorcycle Other:	**Mode used ✓** Car Bus Train Cycle Walk Motorcycle Other:	**Mode used ✓** Car Bus Train Cycle Walk Motorcycle Other:	**Mode used ✓** Car Bus Train Cycle Walk Motorcycle Other:
Origin **Destination**	**Origin** **Destination**	**Origin** **Destination**	**Origin** **Destination**
Journey time Depart: ___________am/pm Arrive: am/pm	**Journey time** Depart: ___________am/pm Arrive: am/pm	**Journey time** Depart: ___________am/pm Arrive: am/pm	**Journey time** Depart: ___________am/pm Arrive: am/pm
Distance: Miles/Km (odometer reading if possible)	**Distance: Miles/Km** (odometer reading if possible)	**Distance: Miles/Km** (odometer reading if possible)	**Distance: Miles/Km** (odometer reading if possible)
Travelling with: 1 other person __________people Alone	**Travelling with:** 1 other person _________ people Alone	**Travelling with:** 1 other person _________ people Alone	**Travelling with:** 1 other person _________ people Alone

Appendix 4: main survey interview questionnaire

Interview Questionnaire

Section 1: Quality of life

1.1. To what extent do you agree or disagree with the following statements?

	Very strongly disagree	Strongly disagree	Disagree	Neither	Agree	Strongly agree	Very strongly agree
The impacts of global warming worry me							
Everyone should try to be more energy efficient							
I never think about the effects of local air pollution							
The destruction of tropical rainforests worries me							
More alternative energy (wind, solar, hydro) should be used							
The use of artificial fertilizers and pesticides does not worry me							
Recycling is a waste of time							
I'm not worried about sea levels rising							
I'm concerned about the loss of plant and animal							

species in the UK							
Pollution of the waterways does not effect me							

1.2 Are there any specific problems that you would associate with current levels of road traffic?

1.3 Are the following statements true or false? (Flash cards)

	True	**Not sure**	**False**
The majority of local air pollution results from road transport			
Exposure to air pollution is the cause of 24,000 premature deaths each year in the UK			
Exhaust emissions from road transport are the main source of lead emissions in the UK			
Emissions from road transport account for 48% of total UK Carbon Dioxide emissions.			
Emissions from road transport contain high levels of known carcinogens			
Emissions from road transport account for 22% of total UK Carbon Monoxide emissions.			
Road transport is the biggest source of UK Nitrogen Oxides emissions			
Pollution levels inside vehicles can be up to 18 times higher than those outside			
Road traffic accidents are the main cause of premature death in the UK			
Emissions from road transport are strongly linked with allergies			

1.4 Do you think global warming is a serious threat?

Section 2: The Tradable Carbon Permit system

(Interviewees are informed of TCP system and shown the software)

2.1 If the Tradable Carbon Permit system were introduced next month, would you try to consume within your free permit allocation where availability is certain or consume above the free allocation where availability is uncertain?

2.2 In the long-term, what is the likelihood that you will do any of the following:

Car share at least once each week

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Move house to live closer to work

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Change job to work closer to home

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Telecommute at least one day each week

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Have shopping delivered/order online

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Buy an alternatively fuelled vehicle

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Buy a more fuel efficient vehicle than current

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Use public transport to work at least once a week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Cycle to work at least once each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Walk to work at least once each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

2.2a) Are there any other changes, not mentioned above, that you are likely to make to your travel behaviour in the long-term?

2.3 Do you foresee any impacts upon your lifestyle resulting from the changes discussed?

None at all 0 1 2 3 4 5 6 **Very many**

2.4 How do you view these changes overall?

Very negative -3 -2 -1 0 +1 +2 +3 **Very positive**

2.5 Would anything make it difficult for you to adapt to the Tradable Carbon Permit system?

2.6 Are there any measures that would help you to adapt to the Tradable Carbon Permit system?

2.7 Do you think there would be any personal and/or societal benefits or costs arising from the implementation of a Tradable Carbon Permit system?

Personal

Very many costs -3 -2 -1 0 +1 +2 +3 **Very many benefits**

Societal

Very many costs -3 -2 -1 0 +1 +2 +3 **Very many benefits**

2.8 Do you think the Tradable Carbon Permit system would be:

To yourself

Very unfair -3 -2 -1 0 +1 +2 +3 **Very fair**

To society

Very unfair -3 -2 -1 0 +1 +2 +3 **Very fair**

Why?

2.9 How effective do you think the Tradable Carbon Permit system could be in achieving a 60% reduction of CO_2 emissions from personal transport by 2050?

Not at all effective 0 1 2 3 4 5 6 **Very effective**

Why?

2.10 Do you expect the Tradable Carbon Permit system to have an impact upon the following?

	Very much worse	Much worse	Worse	No change	Improved	Much improved	Very much improved
Greenhouse gas emissions							
Local air pollution							
Local noise pollution							

Provision of local amenities e.g., shops							
Public health							
Traffic congestion							
Public transport services							
Access to amenities							
Cost of transport							
Social exclusion							
Frequency of road accidents							

2.11 Do you personally consider the Tradable Carbon Permit system to be:

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

Why?

2.12 What was the most important factor when rating your acceptability of the Tradable Carbon Permit system?

2.13 How do you think society as a whole would consider the Tradable Carbon Permit system?

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

2.14 Would you alter any aspect of the system in order to make it more acceptable to yourself/society?

2.15 If these changes were made, how would you then consider the system?

Personally:

Completely unacceptable							**Completely acceptable**
	-3	-2	-1	0	+1	+2	+3

To society:

Completely unacceptable							**Completely acceptable**
	-3	-2	-1	0	+1	+2	+3

2.16 How would you feel about the inclusion of air transport in the Tradable Carbon Permit scheme?

2.17 If air transport were included in the Tradable Carbon Permit scheme, would this affect your use of air transport, considering that air travel requires approximately 4.5 times more Carbon per passenger kilometre than car travel? How?

Section 3: Fuel price

(Respondents are given information about the fuel price increases).

3.1 If the fuel price increases were introduced next month, would you try to maintain current weekly spending on fuel?

3.2 In the long-term, what is the likelihood that you will do any of the following:

Car share at least twice each week

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Move house to live closer to work

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Change job to work closer to home

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Telecommute at least one day each week

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Having shopping delivered/shop online

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Buy an alternatively fuelled vehicle

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Buy a more fuel efficient vehicle than current

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Use public transport to work at least twice a week

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Cycle to work at least twice each week

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

Walk to work at least twice each week

Very unlikely	-3	-2	-1	0	+1	+2	+3	**Very likely**

3.2a) Are there any other changes, not mentioned above, that you are likely to make to your travel behaviour in the long-term?

3.3 Do you foresee any impacts upon your lifestyle resulting from the changes discussed?

None at all 0 1 2 3 4 5 6 **Very many**

3.4 How do you view these changes overall?

Very negative -3 -2 -1 0 +1 +2 +3 **Very positive**

3.5 Would anything make it difficult for you to adapt to the fuel price increases?

3.6 Are there any measures that would help you to adapt to the fuel price increases?

3.7 Do you think there would be any personal and/or societal benefits or costs arising from the fuel price increases?

Personal

Very many costs -3 -2 -1 0 +1 +2 +3 **Very many benefits**

Societal

Very many costs -3 -2 -1 0 +1 +2 +3 **Very many benefits**

3.8 Do you think the increases in fuel price would be:

To yourself

Very unfair -3 -2 -1 0 +1 +2 +3 **Very fair**

To society

Very unfair -3 -2 -1 0 +1 +2 +3 **Very fair**

Why?

3.9 How effective do you think increasing the price of fuel could be in achieving a 60% reduction of CO_2 emissions from personal transport by 2050?

Not at all effective 0 1 2 3 4 5 6 **Very effective**

Why?

3.10 Do you expect an increase in fuel price to have an impact upon the following?

	Very much worse	Much worse	Worse	No change	Improved	Much improved	Very much improved
Greenhouse gas emissions							
Local air pollution							
Local noise pollution							
Provision of local amenities e.g., shops							
Public health							
Traffic congestion							
Public transport services							
Access to amenities							
Cost of transport							

Social exclusion							
Frequency of road accidents							

3.11 Do you personally consider the increase in fuel price to be:

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

Why?

3.12 What was the most important factor when rating your acceptability of the fuel price increases?

3.13 How do you think society as a whole would consider the increase in fuel price?

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

3.14 How do you feel about fuel price increases being applied to air transport?

3.15 If fuel price increases were applied to air transport, would this affect your use of air transport, considering that air travel requires approximately 4.5 times more carbon per passenger kilometre than car travel? How?

3.16 Which measure do you consider most effective at achieving a 60% reduction of CO_2 emissions from personal transport by 2050, the Tradable Carbon Permit scheme or the fuel price increases?

Why?

3.17 Which measure do you consider most acceptable, the Tradable Carbon Permit scheme or the fuel price increases?

Why?

3.18 Is there any measure that you feel would be more effective than increasing the price of fuel or a Tradable Carbon Permit scheme at reducing CO_2 from the transport sector? Why?

Appendix 5: Description of the TCP scheme used during the interviews

The Tradable Carbon Permit system

Purpose/aim?

The purpose of the Tradable Carbon Permit scheme is to reduce CO_2 emissions from personal road transport by 60% by 2050. This target is in line with the governments aim to reduce total UK CO_2 by 60% by 2050.

How will this target be achieved?

CO_2 emissions will be reduced by gradually reducing the amount of Carbon available for road transport each year. There is an absolute limit on the amount of Carbon that can be consumed each year.

This is how the scheme works:

Everyone aged 18 and over will receive a carbon card. This electronic swipe card will hold your Carbon account and will work in a similar way to bank accounts. Each person will receive a free allocation of Carbon permits each year and these will be added to your Carbon account. To give you an idea of the amount, in the first year you'll receive around 250 kilograms of Carbon. This will gradually be reduced each year in line with the Carbon budget, which is simply the total amount of Carbon available in any one year. The remainder of the permits will be released for sale.

Each time you purchase fuel your card will be swiped and the corresponding amount of Carbon permits will be removed from your account. For example, if you buy fuel containing one kilogram of carbon, you hand over carbon permits worth one kilogram of carbon. To give you an idea, a litre of fuel contains around 600 grams of Carbon. If you don't have enough permits in your account, you can buy them at the fuel station. If you didn't use your free permit allocation, you could sell it through a central market using the internet, at the fuel station or the post office.

Public transport?

You won't need any Carbon permits to use public transport. There will be a separate Carbon Permit Trading scheme set up between the public transport operators.

Use of permit revenue?

The revenue will be used to pay for the set up and running costs of the TCP scheme. A proportion will be invested into public transport to be used for service improvements. Any net revenue will be invested into a range of measures that reduce the need to travel, such as local shops.

Any questions?

Appendix 6: Description of the FPI used during the interviews

The fuel price scheme

Purpose/aim?

The purpose of the fuel price scheme is to reduce CO2 emissions from personal road transport by 60% by 2050. This target is in line with the governments aim to reduce total UK CO2 by 60% by 2050.

How will this target be achieved?

CO2 emissions will be reduced by gradually increasing the price of fuel based on evidence of how people respond to fuel price increases.

What does this mean for the individual?

The price of fuel will increase each year.

Use of revenue?

The revenue will be used to pay for the set up and running costs of the fuel price scheme. A proportion will be invested into public transport to be used for service improvements. Any net revenue will be invested into a range of measures that reduce the need to travel, such as local shops.

Any questions?

Appendix 7: Pre-pilot interview questionnaire

Section 1: Quality of life

1. Please rank the importance of each of the following issues, where 1 is very unimportant and 7 is very important *(flash cards)*:

	1	**2**	**3**	**4**	**5**	**6**	**7**
Immigration							
Terrorism							
European constitution							
National unemployment figures							
Quality of health care provision							
Standard of education provision							
War							
Crime/vandalism							
England not winning the European football championship							
Environmental pollution							
Transport							

2. To what extent do you agree or disagree with the following statements?

	Very strongly disagree	Strongly disagree	Disagree	Not sure	Agree	Strongly agree	Very strongly agree
The impacts of global warming worry me							
Everyone should try to be more							

energy efficient							
I never think about the effects of local air pollution							
I am concerned about environmental pollution							
More alternative energy (wind, solar, hydro) should be used							
Air pollution does not effect me							
Recycling waste is a great idea							
Environmental problems cannot be ignored							
My personal contribution to environmental pollution is not great enough to warrant a reduction							
Global warming is a serious problem							

3. Are there any specific problems that you would associate with current levels of road traffic?

4. Does road transport contribute to the following? (flash cards)

Global warming

No contribution **1 2 3 4 5 6 7** Very significant contribution

Local air pollution

No contribution **1 2 3 4 5 6 7** Very significant contribution

Local noise pollution

No contribution **1 2 3 4 5 6 7** Very significant contribution

Depletion of natural resources

No contribution **1 2 3 4 5 6 7** Very significant contribution

Destruction of wildlife habitats

No contribution **1 2 3 4 5 6 7** Very significant contribution

Water pollution

No contribution **1 2 3 4 5 6 7** Very significant contribution

5. Would you associate any particular pollutants with road transport and/or transport emissions?

6. Would you associate any particular illnesses/health effects with road transport and/or transport emissions?

Section 2: The Tradable Carbon Permit scheme

(Interviewees are informed of TCP scheme)

1. If the Tradable Carbon Permit scheme were introduced next month, would you change the way you travel?

(Software employed at this stage to record any changes to travel behaviour and to assess the impact of the stated changes upon carbon consumption).

2. How would your response differ as the system progresses? i.e. how would you adapt to annual reductions of fuel availability in the long-term (use prompts if necessary)?

- Working from home a feasible option?
- Use of clean modes for some trips, e.g. cycle to work?
- Investment in clean fuel technology?
- Online shopping?
- Reduction of leisure journeys/use of alternative mode?
- Change occupation/job transfer to nearer location?
- Move house?

3. Do you foresee any impacts upon your lifestyle resulting from the changes discussed?

4. How do you view these changes (e.g., positive, negative)?

5. Are there any measures that would help you to adapt to the system?

6. Would anything make it difficult for you to adapt to the system?

7. How could the following organisations support your adaptation to the Tradable Carbon Permit scheme?

- o Government
- o Public transport operators
- o Vehicle manufacturers
- o Fuel producers

8. How effective do you think the Tradable Carbon Permit scheme could be in achieving a 60% reduction of CO_2 emissions from personal transport?

Not at all effective 1 2 3 4 5 6 7 **Very effective**

9. Do you think there would be any personal and/or societal benefits arising from the implementation of a Tradable Carbon Permit scheme?

10. Do you think there would be any personal and/or societal costs arising from the implementation of a Tradable Carbon Permit scheme?

11. Do you expect the Tradable Carbon Permit scheme to have an impact upon the following?

	Very much worse	Much worse	Worse	No change	Improved	Much improved	Very much improved
Greenhouse gas emissions							
Local air pollution							
Local noise pollution							
Provision of local amenities							
Public health							
Traffic congestion							
Public transport services							

Access to amenities							
Cost of transport							
Social exclusion							
Frequency of road accidents							

12. Overall, do you think the scheme would be:

To yourself

Very negative -3 -2 -1 0 1 2 3 **Very positive**

To society

Very negative -3 -2 -1 0 1 2 3 **Very positive**

13. Do you personally consider the scheme to be:

Completely unacceptable **Completely acceptable**

1 2 3 4 5 6 7

Why?

14. How do you think society as a whole would consider the system?

Completely unacceptable **Completely acceptable**

1 2 3 4 5 6 7

15. How do you think the permits should be allocated?

16. How should any net revenue be used?

17. Would you alter any aspect of the scheme in order to make it more acceptable to yourself/society?

Section 3: Fuel price

As an alternative measure to the Tradable Carbon Permit scheme, fuel prices could be increased to achieve a 60% reduction of CO_2 from personal transport between 2005 and 2050.

1. If the increase in fuel prices were introduced next month, how would you respond?

2. How effective do you think increasing the price of fuel could be in achieving a 60% reduction of CO_2 emissions from personal transport?

Not at all effective 1 2 3 4 5 6 7 **Very effective**

3. Do you think there would be any personal and/or societal benefits arising from increasing the price of fuel?

4. Do you think there would be any personal and/or societal costs arising from increasing the price of fuel?

5. Do you expect an increase in fuel price to have an impact upon the following?

	Very much worse	Much worse	Worse	No change	Improved	Much improved	Very much improved
Greenhouse gas emissions							
Local air pollution							
Local noise pollution							
Provision of local amenities							
Public health							
Traffic congestion							
Public transport services							
Access to amenities							

Cost of transport							
Social exclusion							
Frequency of road accidents							

6. Do you think the system would be:

To yourself

Very negative -3 -2 -1 0 1 2 3 **Very positive**

To society

Very negative -3 -2 -1 0 1 2 3 **Very positive**

7. Do you personally consider the increase in fuel price to be:

Completely unacceptable **Completely acceptable**

1 2 3 4 5 6 7

Why?

8. How do you think society as a whole would consider the increase in fuel price?

Completely unacceptable **Completely acceptable**

1 2 3 4 5 6 7

10. Is there any measure that you feel would be more effective than increasing the price of fuel or a Tradable Carbon Permit scheme at reducing CO_2 from the transport sector? Why?

Appendix 7: Pilot interview questionnaire

Section 1: Quality of life

1.1. To what extent do you agree or disagree with the following statements?

	Very strongly disagree	Strongly disagree	Disagree	Neither	Agree	Strongly agree	Very strongly agree
The impacts of global warming worry me							
Everyone should try to be more energy efficient							
I never think about the effects of local air pollution							
The destruction of tropical rainforests worries me							
More alternative energy (wind, solar, hydro) should be used							
The use of artificial fertilizers and pesticides does not worry me							
Recycling is a waste of time							
I'm not worried about sea levels rising							
I'm concerned about the loss of plant and animal species in the UK							
Pollution of the waterways does not effect me							

1.2 Are there any specific problems that you would associate with current levels of road traffic?

1.3 How much does road transport contribute to the following? (Flash cards)

The contribution of road transport to UK Carbon Dioxide emissions is:

0 - 20% 21 - 40% 41 - 60% 61 - 80% 81 - 100% Not sure

The contribution of road transport to UK Particulate Matter emissions is:

0 - 20% 21 - 40% 41 - 60% 61 - 80% 81 - 100% Not sure

The contribution of road transport to UK Carbon Monoxide emissions is:

0 - 20% 21 - 40% 41 - 60% 61 - 80% 81 - 100% Not sure

The contribution of road transport to UK Nitrogen Oxide emissions is:

0 - 20% 21 - 40% 41 - 60% 61 - 80% 81 - 100% Not sure

The contribution of road transport to UK Lead emissions is:

0 - 20% 21 - 40% 41 - 60% 61 - 80% 81 - 100% Not sure

1.4 Do you think global warming is a serious threat?

Section 2: The Tradable Carbon Permit scheme

(Interviewees are informed of TCP scheme and shown the software)

2.1 If the Tradable Carbon Permit scheme were introduced next month, would you try to consume within your free permit allocation where availability is certain or consume above the free allocation where availability is uncertain?

2.2 How would your response differ as the system progresses? i.e. are there any other things you might do in the long-term?

a)

in the long-term, what is the likelihood that you will do any of the following:

Car share at least twice each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Move house to live closer to work

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Change job to work closer to home

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Telecommute at least one day each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Have shopping delivered/order online

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Buy an alternatively fuelled vehicle

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Buy a more fuel efficient vehicle than current

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Use public transport to work at least once a week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Cycle to work at least once each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Walk to work at least once each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

2.3 Do you foresee any impacts upon your lifestyle resulting from the changes discussed?

None 0 1 2 3 4 5 6 **Very many**

2.4 How do you view these changes overall?

Very negative -3 -2 -1 0 +1 +2 +3 **Very positive**

2.5 Would anything make it difficult for you to adapt to the Tradable Carbon Permit scheme?

2.5 Are there any measures that would help you to adapt to the Tradable Carbon Permit scheme?

2.7 Do you think there would be any personal and/or societal benefits or costs arising from the implementation of a Tradable Carbon Permit scheme?

Personal

Very many costs -3 -2 -1 0 +1 +2 +3 **Very many benefits**

Societal

Very many costs -3 -2 -1 0 +1 +2 +3 **Very many benefits**

2.8 Do you think the Tradable Carbon Permit scheme would be:

To yourself

Very unfair -3 -2 -1 0 +1 +2 +3 **Very fair**

To society

Very unfair -3 -2 -1 0 +1 +2 +3 **Very fair**

Why?

2.9 How effective do you think the Tradable Carbon Permit scheme could be in achieving a 60% reduction of CO_2 emissions from personal transport by 2050?

Not at all effective 0 1 2 3 4 5 6 **Very effective**

Why?

2.10 Do you expect the Tradable Carbon Permit scheme to have an impact upon the following?

	Very much worse	Much worse	Worse	No change	Improved	Much improved	Very much improved
Greenhouse gas emissions							
Local air pollution							
Local noise pollution							
Provision of local amenities e.g., shops							
Public health							
Traffic congestion							
Public transport services							
Access to amenities							
Cost of transport							

Social exclusion							
Frequency of road accidents							

2.11 Do you personally consider the Tradable Carbon Permit scheme to be:

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

Why?

2.12 What was the most important factor when rating your acceptability of the Tradable Carbon Permit scheme?

2.13 How do you think society as a whole would consider the Tradable Carbon Permit scheme?

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

2.14 Would you alter any aspect of the scheme in order to make it more acceptable to yourself/society?

2.15 If these changes were made, how would you then consider the system?

Personally:

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

To society:

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

2.16 How would you feel about the inclusion of air transport in the Tradable Carbon Permit scheme?

2.17 If air transport were included in the Tradable Carbon Permit scheme, would this affect your use of air transport, considering that air travel requires approximately 4.5 times more Carbon per passenger kilometre than car travel? How?

Section 3: Fuel price

(Respondents are given information about the fuel price increases).

3.1 If the fuel price increases were introduced next month, would you try to maintain current weekly spending on fuel?

(Software used to record and display any changes made to travel behaviour).

3.2 How would your response differ as the system progresses? i.e. are there any other things you might do in the long-term?

a) in the long-term, what is the likelihood that you will do any of the following:

Car share at least twice each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Move house to live closer to work

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Change job to work closer to home

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Telecommute at least one day each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Having shopping delivered/shop online

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Buy an alternatively fuelled vehicle

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Buy a more fuel efficient vehicle than current

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Use public transport to work at least twice a week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Cycle to work at least twice each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

Walk to work at least twice each week

Very unlikely -3 -2 -1 0 +1 +2 +3 **Very likely**

3.3 Do you foresee any impacts upon your lifestyle resulting from the changes discussed?

None 0 1 2 3 4 5 6 **Very many**

3.4 How do you view these changes overall?

Very negative -3 -2 -1 0 +1 +2 +3 **Very positive**

3.5 Would anything make it difficult for you to adapt to the fuel price increases?

3.6 Are there any measures that would help you to adapt to the fuel price increases?

3.7 Do you think there would be any personal and/or societal benefits or costs arising from the fuel price increases?

Personal

Very many costs -3 -2 -1 0 +1 +2 +3 **Very many benefits**

Societal

Very many costs -3 -2 -1 0 +1 +2 +3 **Very many benefits**

3.8 Do you think the increases in fuel price would be:

To yourself

Very unfair -3 -2 -1 0 +1 +2 +3 **Very fair**

To society

Very unfair -3 -2 -1 0 +1 +2 +3 **Very fair**

Why?

3.9 How effective do you think increasing the price of fuel could be in achieving a 60% reduction of CO_2 emissions from personal transport by 2050?

Not at all effective 0 1 2 3 4 5 6 **Very effective**

Why?

3.10 Do you expect an increase in fuel price to have an impact upon the following?

	Very much worse	Much worse	Worse	No change	Improved	Much improved	Very much improved
Greenhouse gas emissions							
Local air pollution							
Local noise pollution							
Provision of local amenities e.g., shops							
Public health							
Traffic congestion							
Public transport services							
Access to amenities							
Cost of transport							
Social exclusion							
Frequency of road accidents							

3.11 Do you personally consider the increase in fuel price to be:

Completely unacceptable **Completely acceptable**

-3 -2 -1 0 +1 +2 +3

Why?

3.12 What was the most important factor when rating your acceptability of the fuel price increases?

3.13 How do you think society as a whole would consider the increase in fuel price?

Completely unacceptable							**Completely acceptable**
-3	-2	-1	0	+1	+2	+3	

3.14 How do you feel about fuel price increases being applied to air transport?

3.15 If fuel price increases were applied to air transport, would this affect your use of air transport, considering that air travel requires approximately 4.5 times more Carbon per passenger kilometre than car travel? How?

3.16 Which measure do you consider most effective at achieving a 60% reduction of CO_2 emissions from personal transport by 2050, the Tradable Carbon Permit scheme or the fuel price increases?
Why?

3.17 Which measure do you consider most acceptable, the Tradable Carbon Permit scheme or the fuel price increases?
Why?

3.18 is there any measure that you feel would be more effective than increasing the price of fuel or a Tradable Carbon Permit scheme at reducing CO_2 from the transport sector?

Appendix 9: Screening questionnaire

Pre-interview questionnaire

Availability of car (please delete as appropriate):

0 cars   1 car   2+ cars

Estimated annual distance travelled by car (please state Miles or Kilometres):

Main mode used for all journeys (please delete as appropriate):

Car   Bus   Train   Bike   Walk

Other (please state):

Postcode:

Male/female:

Appendix 10: Respondent information

ID	Behavioural change		Car availability	Annual car mileage	Main mode	Gender	Post code	Carbon kg/week
number	TCP	FPI						
1	YES	YES	1	9,000	Car	F	LS18	8.9
2	YES	YES	1	9,000	Car	F	LS29	16.9
3	NO	NO	2+	5,000	Car	F	LS17	22.9
4	NO	NO	0	1,500	Walk	M	LS2	0.6
5	NO	NO	1	11,000	Bus	M	YO30	2.7
6	NO	NO	1	5,000	mope	F	LS25	5.7
7	NO	NO	2+	20,000	Car	M	YO24	16.8
8	YES	NO	1	9,000	Car	F	LS10	6.2
9	NO	NO	0	0	Bus	F	LS11	1.3
10	YES	NO	2+	17,000	Car	M	S36	22.1
11	NO	NO	1	7,000	Car	F	LS17	9.1
12	YES	NO	2+	36,000	Car	M	DN21	57.9
13	NO	NO	0	0	Bus	F	LS12	0.2
14	YES	NO	1	8,500	Car	F	LS21	9.6
15	NO	NO	1		Car	F		7.4
16	NO	NO	2+	8,500	Car	M	LS15	9.4
17	NO	YES	1	7,000	Car	M	LS11	4.3
18	NO	NO	1	2,600	Train	F	BD16	2.2
19	YES	YES	2	6000	Car	F	LS6	4.3
20	YES	YES	0	2,000	Cycle	M	LS13	25.8
21	NO	YES	1	780	Car	F	LS9	2.8
22	NO	NO	2+	16,000	Car	M	LS12	17.4
23	NO	NO	1	7,000	Car	F	LS16	6.6
24	NO	NO	0	0	Bus	F	LS13	0.7
25	NO	NO	1	9,000	Car	F	BD11	5.1
26	NO	NO	0	300	Cycle	F	LS7	1.5
27	YES	NO	1	12,000	Car	F	LS21	16.7
28	NO	NO	0	0	Train	F	DN1	0.0
29	YES	YES	1	20,000	Car	F		23.9
30	NO	NO	0	500	Walk	F	LS2	0.1
31	NO	NO	1	3,000	Car	F	LS6	0.2

32	YES	NO	1	11,000	Car	F	LS25	7.2
33	NO	NO	2	8,000	Car	F	LS18	6.2
34	NO	NO	1	5,000	Car	M	BD10	2.8
35	YES	NO	2	13,000	Car	M	HD7	6.6
36	NO	NO	0	500	Train	M	HD1	0.4
37	NO	NO	1	2,500	Car	F	LS16	1.9
38	NO	NO	2	7,600	Car	F	LS21	0.5
39	YES	YES	1	10,000	Car	M	BD17	15.6
40	YES	NO	1	15,600	Car	F	WF9	10.9
41	NO	NO	1	3,000	Bus	M	LS18	2.7
42	NO	NO	1	6,000	Car	F	LS26	10.5
43	NO	NO	1	400	Bus	M	LS27	0.6
44	NO	NO	2	4,000	Car	M	LS25	6.7
45	NO	NO	1	1,800	Walk	F	YO10	0.9
46	NO	NO	0	2,000	Bus	F	LS16	0.3
47	YES	NO	2	16,000	Car	F	YO41	18.3
48	NO	NO	1	6,000	Car	F	LS6	2.3
49	YES	YES	1	2,000	Car	M	LS6	18.6
50	NO	NO	1	0	Train	F	HD7	0.6
51	NO	NO	2	5,000	Car	M	LS17	13.1
52	YES	NO	2	6,000	Car	M	LS17	16.3
53	NO	NO	1	400	Walk	F	LS10	0.0
54	NO	NO	1	1,000	Bus	F	LS19	2.9
55	NO	NO	1	9,000	Car	M	LS25	7.2
56	YES	YES	2	14,000	Car	M	S35	31.4
57	YES	NO	2	8,000	Car	F		15
58	NO	YES	1	10,000	Car	M	WF5	11.9
59	NO	NO	0	50	Bus	M	LS19	0.0
60	YES	YES	1	9,000	Car	F	LS18	8.9