Reducing carbon emissions from personal road transport through the application of a Tradable Carbon Permit scheme: Empirical findings and policy implications from the UK

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1. Introduction

Climate change is an urgent issue rapidly reaching the top of the political agenda. Greenhouse gases (GHG) 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). 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. In addition, the IPCC (2007) have medium confidence regarding the anthropogenic influence on human systems. 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 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 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). Hence, whilst transportation is an intrinsic part of society and current lifestyles (Lyons *et al.,* 2002; Anable, 2005), the transport sector makes a significant contribution to GHG emissions. For example, in the UK, road transport alone currently accounts for 26% of UK CO2 emissions, the majority resulting from personal use (DfT, 2006a). 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 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). Hence, whilst the measures are likely to have an impact on CO_2 emissions they 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 with a high degree of confidence (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.

This paper provides the first set of empirical data regarding the public response to a personal carbon trading scheme applied to personal road transport in the UK. With the aim of contributing to the growing debate regarding the application of pricing or trading measures to achieve emissions reductions (Keay-Bright and Fawcett, 2005; Raux and Marlot, 2005), a system of fuel price increases designed to achieve the same emissions target was also explored. This paper provides unique empirical data focusing on the behavioral response, impacts, fairness, perceived effectiveness and acceptability of both measures and provides a range of policy implications intended to steer policy direction in this highly important and largely undiscovered research area. Section 2 provides background information on the policies explored whilst section 3 outlines the policies designed for the purpose of this research. Section 4 details the survey methodology with survey results presented in section 5. Finally, section 6 contains the research conclusions and implications for policy makers.

2. Policy background

Tradable Permit (TP) schemes are regulatory 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 in meeting emissions targets, as those who pollute over their assigned amount of permits are able to purchase additional permits from those who pollute below their threshold and subsequently have excess permits, thus enabling new requirements to be achieved in a more cost effective manner.

In a typical TP scheme, a target would be set (e.g. an emissions target), and the purpose of the scheme and the geographic area to be covered would be clearly defined. By distributing a certain amount of permits, the regulatory body is then able to control levels of pollution in line with the overall target, a process referred to as ‘cap and trade’ (Crals *et al*., 2003). Those affected by the system would then have to acquire tradable pollution permits equal to an amount of pollution which could then be emitted. The amount of permits available would then be gradually reduced until the target is reached.

To date, TP schemes have been applied to stationary emissions sources with the first scheme (the US Emissions Trading Programme) beginning in the US during the mid 1970’s with the aim of adding flexibility to stationary sources in meeting the air quality standards required by the Clean Air Act 1975 (Tietenberg, 1985). More recently, phase I of the European Emissions Trading Scheme (EU ETS) was introduced across Europe in 2005, with phase II beginning in 2008, coinciding with the first Kyoto Protocol commitment period. The scheme was designed to “promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner” (DIRECTIVE 2003/87/EC) and to 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.

There is a growing political 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".

There is also a growing interest in the use of TP schemes to reduce emissions from motor vehicles i.e. non-point source, or mobile emissions (Raux, 2002; 2004; 2005; Swedish EPA, 2006; Grayling *et al*., 2006). The EU ETS currently includes large point sources of CO_2 emissions, where monitoring is more feasible. However, the experience gained could then be used to extend the programme to regulate small mobile emitters, such as cars (European Commission, 2003). In the EU ETS review, the European Commission focused on 2 options – including car manufacturers and including individual motorists (European Commission, 2006). 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. In addition, 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).

To regulate emissions from individuals, a TP scheme could either be implemented upstream i.e. amongst fuel producers, or downstream i.e. amongst individual consumers. 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 would 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. 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.

In terms of suggested policy outlines for personal carbon trading, there are two main approaches: Domestic Tradable Quota's (DTQ's) and Personal Carbon Allowances (PCA's). DTQ's was originally developed by David Fleming in 1996 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 (DTQ's are also known as Tradable Energy Quotas (Fleming, 2007)). 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. 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 carbon 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. 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 as part of the national identity card scheme, should this be introduced (Starkey and Anderson, 2005).

PCA's were proposed by Hillman and Fawcett (2004) with the aim of significantly reducing 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, to stabilise atmospheric levels of CO_2 at 550ppm, which would require a 60% reduction of CO_2 emissions 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 amongst individuals and the scheme 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.

Within the literature there are several suggestions for TP schemes to reduce fuel used for personal transport amongst individual consumers. Keppens and Vereeck (2003) outline a system of Tradable Fuel Permits (TFP). 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).

Raux and Marlot (2005) describe how a system of decentralised transferable permits could be used to reduce fuel consumed for transport, using the case of France as an example for practical application. 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. The TP scheme would 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.

Fuel tax increases are an alternative approach to TPs. 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.

3. Policy design

In order to measure public response to a personal carbon trading scheme, it was first necessary to design a scheme in sufficient detail for such a purpose. Hence, this section describes the working policy design of the Tradable Carbon Permit (TCP) scheme. The system of purposely designed fuel price increases (FPI) is also described, however, as fuel price increases are a far more familiar instrument, the focus here is on the design of the TCP scheme. Both policies have been designed to be as realistic as possible and hence to serve as policy scenarios in order to measure public response, thus the policy outlines do not intend to fully explore all related technical and implementation issues. Both measures are designed to deliver a reduction in carbon emissions of 60% by 2050 in line with the aim set out by the UK government (DTI, 2003), which is also proposed to become legally binding in the forthcoming Climate Change Bill (DEFRA, 2007). A 2006 start date was used for consistency with the start date used in the surveys (see section 4) and to allow the use of current transport statistics rather than a forecast starting point.

3.1 The TCP scheme

The main features of the scheme including estimated financial costs and permit prices are outlined in the following sections.

3.1.1 Achieving the emissions target

The emissions target would be achieved by placing a limit on the amount of carbon available for road transport (converted into the fuel equivalent) each year, thus creating a carbon budget which would be gradually reduced by 1.34% each year from 1997 levels, for example by 2.68% in 2007; and 4.02% in 2008, 5.36% in 2009 and so on until 2050. The gradual and known reduction in carbon availability allows society to steadily adjust. As the reductions become greater, dependency on carbon consuming modes would be reduced as alternatives, such as clean-fuelled motor vehicles, become available. In addition, the localisation of shops and services would increasingly reduce the need for car use.

3.1.2 Use and distribution of carbon permits

Each year, half of the annual carbon budget would be allocated to individuals free of charge, with each UK citizen aged 17 and over receiving an equal allocation. The allocation method is likely to encourage individuals to reduce their carbon consumption in order to benefit from selling excess permits, thus proving monetary gains to those who change their behavior and to those who are already low carbon consumers. Permits would be traded in a central permit market, requiring a real time database with secure trading facilities. Access points could include fuel stations, post offices and the internet. Current information technology is considered adequately sophisticated to enable the administration of such a scheme (Grayling *et al*., 2006; Starkey and Anderson, 2005). In order to cover operating costs, replace lost fuel tax revenue, and provide investment for public transport improvements, the remaining 50% of the annual carbon budget would be sold through the central permit market by the government. Any surplus permit revenue would be invested into the provision of supportive measures, such as local amenities, telecommunication networks, cycle lanes and footpaths.

The TCP scheme would work on the basis that carbon permits are required in order to purchase fuel for land based personal transportation modes (e.g., car, motorcycle). Each person would have an individual carbon account with an electronic swipe card that must be used when purchasing fuel, and selling or buying permits. In order to reduce the possibility of carbon shortages, the permits for sale would be released gradually throughout the year, for example an equal amount released at each 3-month interval. In addition, there would be a limit on the amount of permits each carbon account could contain at any one point in time. This would reduce the potential to stockpile and thus distort permit availability. Carbon permits would not be required for public transport journeys thus providing an incentive to use such modes. A trading scheme would instead be set up between public transport operators which would commence 5 years after the introduction of the individual permits in order to allow operators to introduce preparatory measures.

Each person would be able to access their account details in real time as all information would be stored on a national electronic database. Research suggests that a database could be based on current technology (Starkey and Anderson, 2005). Carbon accounts could be stored on the identity cards currently being considered by the UK Government (Home Office, 2004), as this would greatly reduce the implementation costs, in addition to providing extra security and therefore reducing the potential of fraudulent permit cards, hence the following section assumes the carbon accounts would be contained within individual identity cards.

3.1.3 Estimated financial costs

The TCP scheme has been designed to be self-funding with respect to operating costs and forgone revenues, see table 3.1.

Table 3.1 Estimated financial costs of TCP scheme: £m 2006 and 2007.

	2006	2007
Lost fuel tax revenue	231.2	462.5
Operating costs	175.1	175.1
Scanning equipment	40.5	-
Information campaign	8.3	-
Public transport investment	139.0	139.0
Total costs	594.1	776.5

As the carbon budget is reduced, the amount of lost fuel tax revenue would increase each year, necessitating an annual increase in permit price. 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 2006 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.

The operating costs are based on those of the UK Driver and Vehicle Licensing Agency, which was considered to be the closest in terms of the similarities in administration requirements and the monitoring of a national database. The estimated cost of scanning equipment would provide a chip and pin machine in each fuel station and post office outlet in the UK. These costs could be reduced if existing machines were adjusted to read the carbon cards. The cost of an advertising campaign conducted by the UK government ‘preparing for emergencies’ was adopted as the requirements (e.g., TV and radio advertisement, leaflets, website and national coverage) were very similar. The annual investment in public transport was derived from the estimated displacement of car journeys onto public transport. The amount of local government expenditure per annum was then used as a guide to estimate the revenue required. For example, if a corresponding reduction of 1.34% is assumed for car passenger kilometres, the displaced kilometres can then be added to public transport kilometres (it is unknown exactly how many car journeys would be displaced) as such: 1.34% of 678 billion passenger kilometres (DfT, 2005a) = 9.0852, causing a 9.46% increase in public transport km (9.0852 = 9.46% of 96 billion public transport passenger km). Local government expenditure on public transport is currently £1462 million (DfT, 2005a), resulting in the addition of £139 million from permit revenue (9.46% of £1462m = £139m). This estimate does not consider the financial profit increases for operators.

3.1.4 Free allocation of carbon permits and estimated permit price

Given that the fundamental requirement of the permit sales would be to cover the costs of the TCP scheme, the total annual cost of the TCP scheme (including replaced fuel tax revenue) 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[1]. Thus, for example, in 2006 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 per kilogram carbon. It was assumed that half of the annual carbon budget would be allocated free of charge to individuals, 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 3.1 displays the estimated price of permits throughout the duration of the TCP scheme.

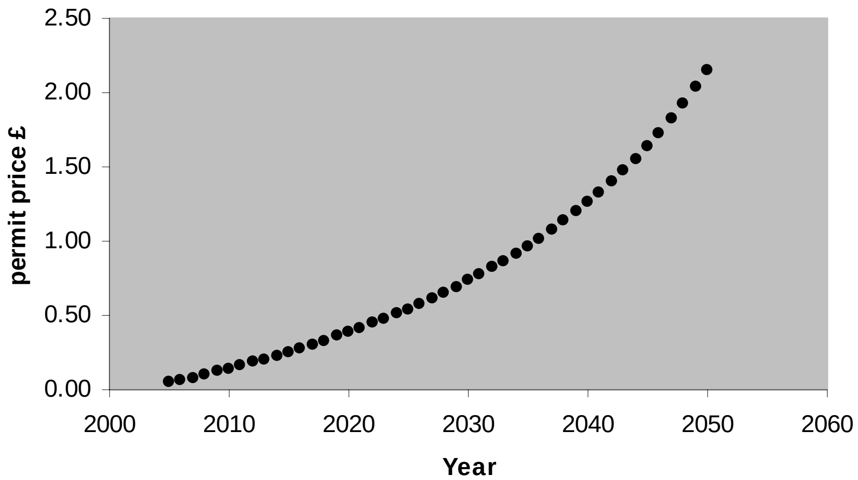

Figure 3.1: Permit price (per kilogram of carbon) during the TCP scheme

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

1 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.

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 3.2 and 3.3 show the free permit allocation and monetary value during the TCP scheme.

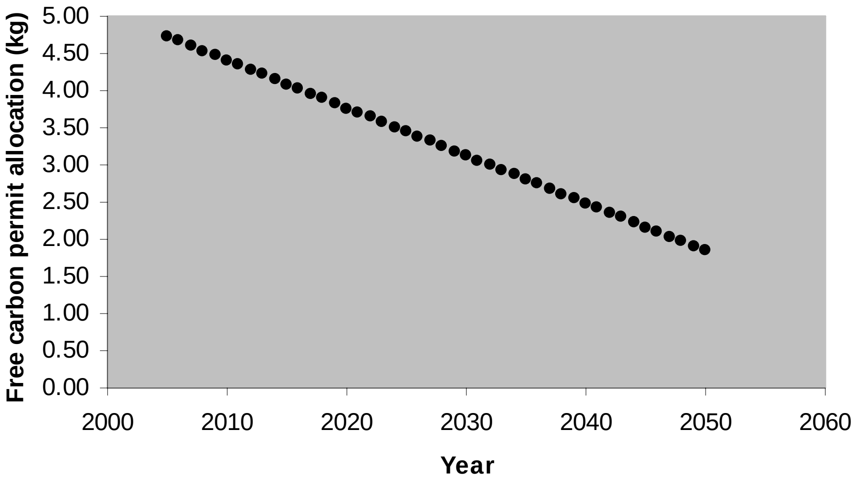

Figure 3.2: Free carbon permit allocation per person per week during the TCP scheme

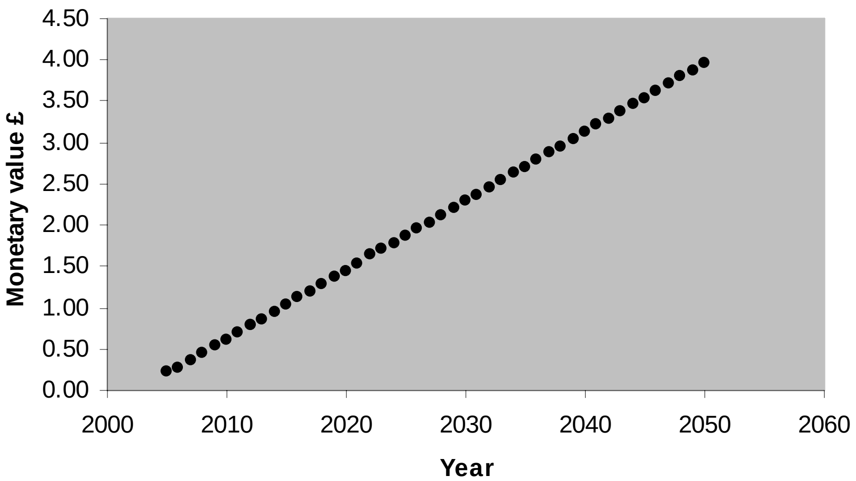

Figure 3.3: Monetary value of free carbon allocation per person per week

3.2 The fuel price increase (FPI)

The emissions target would be achieved by gradually increasing the price of fuel to the level required according to the fuel price elasticity used. Using current fuel prices, a short-range conventional elasticity of fuel demand of -0.25 was applied for the first five years, and then graduated up by -0.05 per year until -0.7 was reached (Glaister and Graham, 2000). This elasticity was then applied thereafter up to 2050. It is recognised that this method has limitations as the long-term response is unlikely to remain the same each year over such a long time period. Figure 3.4 shows the fuel price during the FPI.

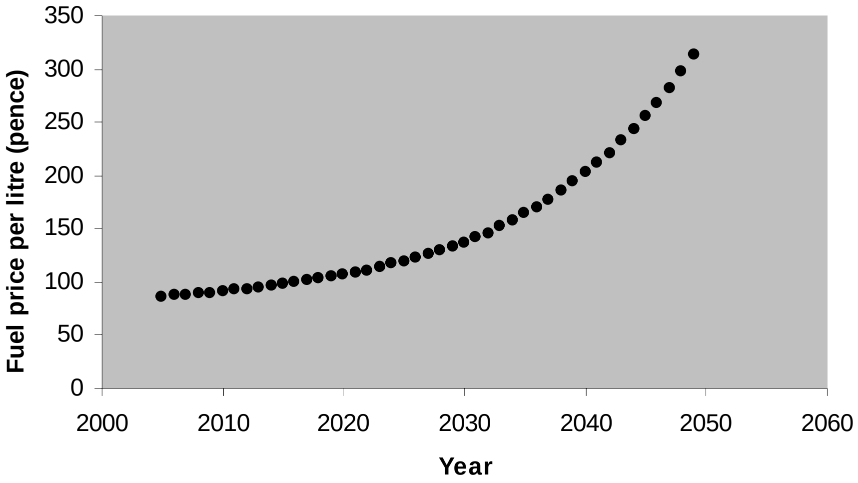

Figure 3.4: Fuel price per litre for the FPI

The fuel price increases 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, which was communicated to respondents during the survey.

4. Survey design and implementation

For the purpose of this research, face to face interviews with individuals were considered the most appropriate method given the public's unfamiliarity with personal carbon trading. The survey was designed to be explorative, hence a range of open and closed questions were used following a formal structure. Given the time restrictions, a total of 60 people were interviewed between February and May 2006 with each interview lasting around 1.5 hours. 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, 2006b), and will therefore have to make the greatest changes in response to the policies. Staff members from two of the largest employers in Leeds - the University of Leeds and 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. In order to avoid over representation of particular groups, such as car users, males/females, and urban dwellers, a screening questionnaire was completed by all interested parties. Respondents then completed and returned a 7-day travel dairy, at which point an interview was arranged.

4.1 Interview procedure

The interview was arranged into three sections, each having a different topic and purpose. The first section was designed to provide a measure of environmental concern, problem perception, and knowledge of transport issues. Section 2 began with an explanation of either the TCP scheme or FPI, followed by questions regarding the behavioural response. Bespoke low carbon software was used, which calculated and displayed current weekly carbon consumption (calculated previously from the travel diary) and estimated weekly fuel expenditure (the low carbon software was originally developed by Bristow *et al*., 2004 before being altered for the current study). The software was designed to provide 2 interfaces, one relating to the TCP scheme, the other relating to the FPI. The software calculated and displayed the free allocation of carbon permits at three points in time: 2010, 2020 and 2030. Carbon consumption (defaulted to current consumption) was displayed alongside each permit allocation, together with the total estimated price of fuel and permits. Respondents were asked how they would respond if the TCP scheme was introduced, and whether they would try to consume within their free allocation or buy extra permits as required if they were available. They were informed that the prices displayed were based on fixed permit prices which could increase if sold on an open market. There was then an opportunity to alter individual journeys according to what respondents considered to be feasible, for example cycling to work rather than using a car. The changes were made within the software and the carbon consumption was recalculated and displayed alongside the corresponding time period. When discussing the FPI, respondents were asked if they would make any changes to their current travel behaviour as a result of the increased fuel costs and changes were made where they were considered to be feasible in each time period. For both polices, respondents were asked to assume that their current circumstances, for example in terms of age and income, would remain the same in each time period. They were told the prices derived by the software did not include inflation or fluctuating oil prices. Figures 4.1 and 4.2 provide examples of the software used to record behavioural response to the TCP scheme and FPI respectively. To demonstrate the price increases (as a result of rising permit prices for the TCP scheme), examples from a respondent who did not make any changes in either policy were selected.

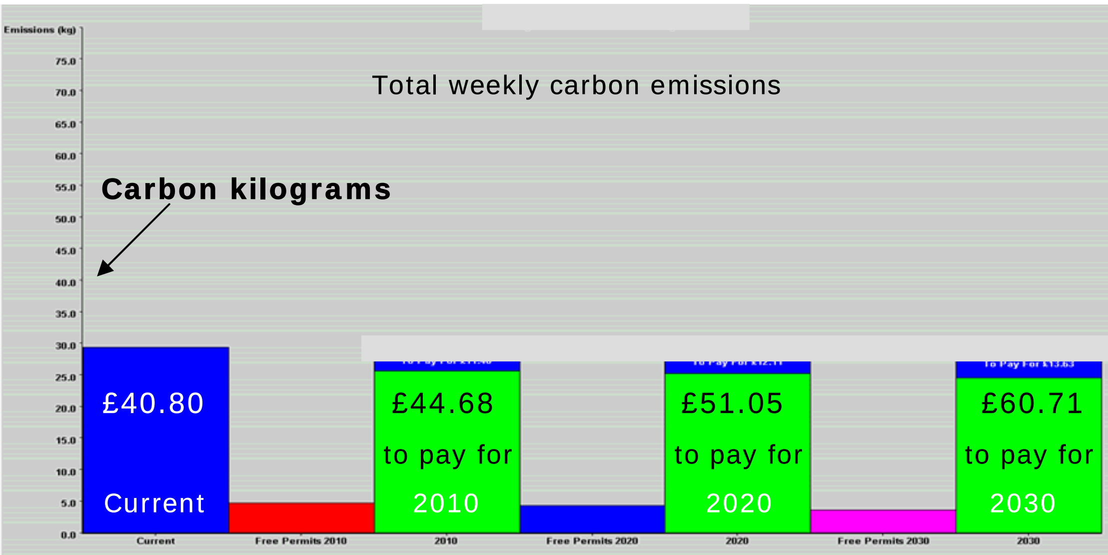

Figure 4.1: Screenshot of the low carbon software used to record behavioural response to the TCP scheme (*Notes: from left to right – current consumption and spending on fuel; free carbon allocation in 2010; carbon consumption in 2010 with estimated spending on fuel and permits; 2020; 2030*).

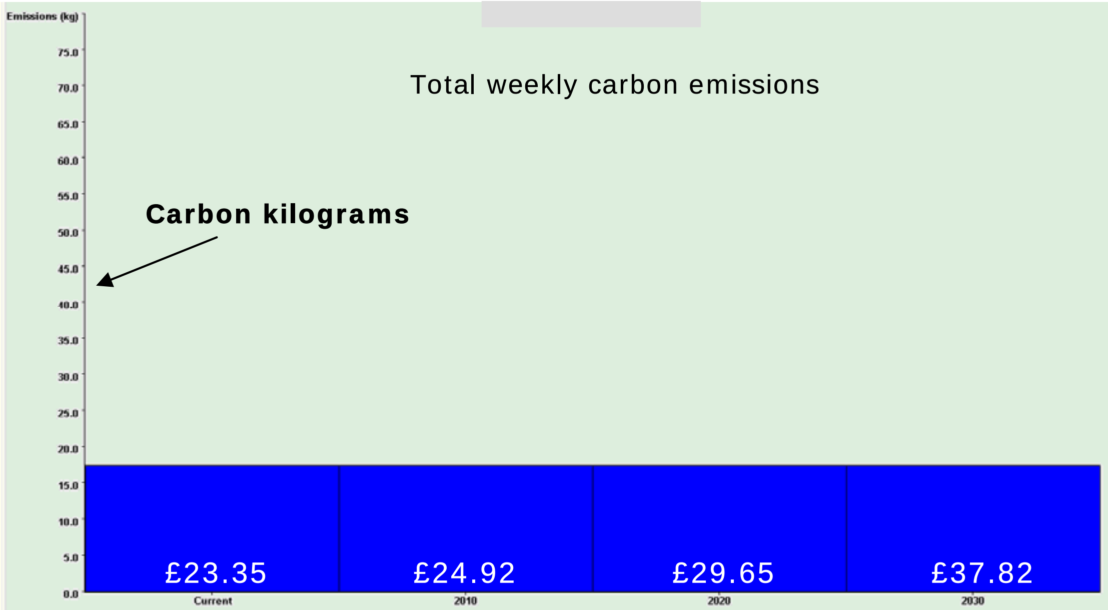

Figure 4.2: Screenshot of the low carbon software used to record behavioural response to the FPI (*Notes: from left to right - Current carbon consumption/week with estimated fuel expenditure; carbon consumption/week in 2010 with estimated fuel expenditure; 2020; 2030).*

After respondents had considered their behavioural response, a series of questions regarding the impacts on lifestyle, costs and benefits, fairness, effectiveness and acceptability followed. In addition to providing a qualitative answer, respondents were also asked to quantify their response to most questions on a likert 7-point scale. To obtain comparable responses, the final section of the interview repeated the previous section for the policy not yet discussed. The order of presentation of the two policies was alternated, therefore reducing the possibility of response bias/fatigue that could occur if the interviews were always conducted in the same order, for example, the trading scheme followed by the pricing scheme. Instead, the trading scheme was discussed first in 50% of the interviews and the pricing policy discussed first in the remaining interviews. Socioeconomic data were collected at the end of the interview.

Response rates were measured at each stage of the study, as shown in table 4.1.

Table 4.1: 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 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 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. Response rates could have possibly 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 section 4.1). 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 4.1 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 4.2 displays the sample characteristics.

Table 4.2 Sample characteristics

Variable	Respondents	UK average
Female	63%	51.2%
Age		38.6 years
18 - 35	53%	
36 - 53	37%	
>54	10%	
Education		11% of population has higher education qualifications
Basic	7%	
Further	18%	
Higher	44%	
Gross household Income/annum		£28, 000
<£10, 000 - £20, 000	27%	
£21, 000 - £40, 000	23%	
>£41, 000	20%	
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)	39.0%	
Average (8,001-9,000)	13.5%	
Above average (>9,001)	47.0%	
Sample average: 12,064 km/person		
Average km travelled per mode[2]		
Car	232.0	178.0
Bus	28.7	10.9
Train	80.2	14.2
Motorcycle	1.1	1.1
Taxi	1.0	1.8
Cycle	4.0	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 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 section 5.2 together with the results recorded by the low carbon software.

5. Survey results

Here the results are discussed, firstly relating to concern for the environment, problem perception and knowledge in section 5.1, followed by the behavioral response and average ratings of impacts, costs and benefits, fairness, effectiveness, and acceptability in sections 5.2 – 5.7.

5.1 Concern for the environment, problem perception and knowledge

The first section of the questionnaire was designed to provide a measure of environmental concern, problem perception and knowledge for each participant as these personal attitudes were considered to be an important factor in terms of acceptability ratings (Fujji *et al.*, 2004).

Environmental concern was measured using 10 items on a 7-point scale, ranging from 'very strongly disagree' to 'very strongly agree'. In order to minimise the

[2] From 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.

risk of response bias, the statements were randomly presented in negative and positive form. The average score of environmental concern was 5.7 (maximum score = 7), thus on average respondents were very concerned about the environment. Cronbach's Alpha is 0.76, indicating an adequate degree of internal consistency that is comparable with other studies reporting 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 the UK Department for Transport (DfT, 2006c), 84% of respondents were very or fairly concerned about environmental issues and 81% were very or fairly concerned about climate change.

Problem perception was measured by asking if any problems were associated with current levels of road transport. On average, each respondent stated 2.6 problems, the main ones being congestion, air pollution and safety. These findings are consistent with those reported by CfIT (2002), where congestion was the most commonly mentioned transport issue with vehicle pollution affecting health and road safety rated as the next most important issues after congestion.

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 (maximum score = 10), thus indicating a low level of knowledge amongst the sample.

5.2 Behavioral response

This section presents the data collected by the low carbon software during the interviews. Table 5.1 shows the prices used in the low carbon software to calculate estimated spending which was shown to respondents in each time period (respondents were not shown the prices in this form – only in terms of their total estimated spending per week as demonstrated in figures 4.1 and 4.2).

Table 5.1: Fuel price (pence) and % increase from base[3] 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

When discussing the TCP scheme, 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.

5.2.1 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

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

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" 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".*

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. 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" and *"I'd just carry on as normal and hope that I'd get the permits I wanted"* and *"I wouldn't care about the cost, I'd pay it if it meant I didn't have to change"* and *"I wouldn't like it but yeh I'd just pay it"* and *"I don't want to hear about climate change, I just want to get on with my life to be honest".*

5.2.2 Behavioural change

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. The changes stated by respondents were in response to an open question, hence suggestions were not provided from the interviewer. The main responses given in relation to the TCP scheme were the use of train to commute to work between 1 and 3 days per week, the use of bus to commute to work for 3 days per week, and walking for short leisure trips. For the FPI, the main response was to use the train to commute to work for 2 days per week. Other responses include using the bus to commute to work between 1 and 5 days per week; car sharing; telecommuting; changing vehicle; cycling to work and working locally (closer to home). Table 5.2 shows the impact of the changes on total kilometres travelled by the whole sample for each policy and time period.

Table 5.2: Total distance (kilometres) traveled for the whole sample per mode[4] 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
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 t-test revealed significant differences between base kilometres and kilometres travelled in 2030 for both the TCP scheme ($p<.02$) and the FPI ($p<.025$). By 2030, in relation to the TCP scheme, car kilometres were below the UK national average (per person) 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 5.3 shows the impact of behavioural change on total carbon consumed by the whole sample for each policy and time period.

Table 5.3: Total carbon consumption from the whole sample (kilograms) per mode[5] 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
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

[4] Taxi and motorcycle did not change from the base level of 59 and 694 kilometres respectively.
[5] Taxi and motorcycle did not change from the base level of 3 and 17 kilograms respectively.

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 section 3.

The percentage reduction in carbon consumed by car use is greater than the corresponding reduction in kilometres traveled by car (see table 5.2). 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. Hence, carbon consumption and demand for permits and fuel were reduced without having to reduce vehicle kilometres travelled. 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.

5.2.3 Policy effectiveness

The data in table 5.3 can be used to assess the effectiveness of each policy in terms of achieving intermediate carbon reduction targets, shown in table 5.4.

Table 5.4: 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 FPI 25.3% reflecting the assumed lower price elasticity in the early years. Table 5.4 shows that, up to 2030, the TCP scheme overachieved each intermediate target whereas the FPI failed to achieve any intermediate target despite having higher fuel prices than the TCP scheme. This implies that the willingness to pay for fuel was higher then expected and that a quantity approach (limiting carbon availability) was a much more effective method of achieving change amongst a group of above average carbon consumers.

Policy effectiveness can also be assessed in terms of the change in kilometers observed between base and 2030 for each 1% of the carbon reduction target in 2030. Table 5.5 shows the results.

Table 5.5: Change in kilometers traveled per mode per week per 1% of the carbon reduction target[6]

	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 (despite the TCP scheme having higher carbon reduction targets, the FPI was the only policy to cause changes amongst the below average income group which was also the only income group to achieve any of the carbon reduction targets related to the FPI).

Up to 2030, the TCP scheme achieved an average effectiveness of 110% compared to the FPI which achieved an average effectiveness of 84%. 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 uncertainty of permit availability appeared to be the main driver for behavioural change, for example:

"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" 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".*

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.

5.3 Impacts on lifestyle

After considering how the policies might affect their travel behavior, respondents were asked if they perceived any impacts on their lifestyles if the policies were introduced, and if these would be considered as positive or negative impacts. 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 for both questions (standard deviation in brackets) are displayed in table 5.6.

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

Table 5.6 Impacts on lifestyle

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

The extent of the perceived impacts on lifestyle were similar for both policies, however, the impacts resulting from the TCP scheme were perceived to be positive, whereas negative impacts were perceived to result from the FPI. The difference between the ratings of impacts for the two policies was tested for significance using a Wilcoxon signed ranks test (equivalent to a paired sample t-test for categorical data). There was no significant difference between the impacts rating, but the difference between the strength of impacts ratings were significant ($p<.005$). In general, respondents felt that the TCP scheme would encourage them to think about the necessity of car use and find alternative modes, resulting in health and fitness benefits, whereas the fuel tax increases would result in increased costs without stimulating the same positive thought process and actions as the TCP scheme, for example:

"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" and *"I'd feel good about it* (TCP scheme)*, knowing that I was doing my bit and staying in my allowance"* and *"This'd* (TCP scheme) *make me think more about the environment than the money aspect"* and *"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".*

These thoughts are demonstrated in tables 5.2 and 5.3, where the behavioral response to the TCP scheme was much greater.

5.4 Costs and benefits

Respondents were asked if there would be any personal costs and/or benefits as a result of the implementation of each policy. Responses were given on a 7-point scale ranging from -3 (very many costs) to 3 (very many benefits). Table 5.7 contains the average ratings (standard deviation in brackets) for each policy.

Table 5.7 Personal and social costs and benefits

	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 fuel tax increases 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. The responses given to an open question regarding the ratings are closely related to those given in relation to the impacts ratings, with the TCP scheme having a greater impact on car use resulting in reduced levels of local air and noise pollution, and improved levels of personal health and fitness. In contrast, the increased cost of fuel was by far the main response given in relation to the FPI with reduced levels of air pollution being the most noted benefit. For example:

"People only lose out from the fuel price increase but people actually benefit from the permit scheme" and *"Not enough people will stop using their cars so there'd be little benefit from the fuel price, people would rather starve than stop using their cars"* and *"Well I'd have to spend more on fuel so that'd be a cost".*

The social benefits were rated to be greater than the personal benefits for both policies, as a result of environmental improvements being considered more as a wider social benefit rather than a personal benefit.

5.5 Fairness

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 5.8.

Table 5.8 Personal and social fairness

	TCP scheme	FPI
Personal rating	1.31 (1.42)	0.46 (1.87)
Social rating	- 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. In relation to the TCP scheme, the most commonly stated reason for considering the policy to be fair was the allocation of carbon permits on an equal per capita basis to be a key factor in the fairness ratings, with those using more than their free allocation having to buy additional permits and therefore incurring extra costs:

"If everyone gets the same then there're no arguments are there" 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"* 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"* and *"It's like the polluter pays because if you use more than your free allowance you've got to start paying"* and *"It says that we're all in it together and we all need to make an effort".*

In contrast, most respondents thought society would generally consider the TCP scheme to be unfair, mainly as a perceived restriction on personal freedom and car use, given the high level of importance placed on car use:

"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" and "People don't like to change".

However, fairness ratings were thought to increase over time as people became accustomed to the scheme and the benefits became visible. The FPI was considered to be less fair, mainly due to the perceived uneven impacts across society:

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

Respondents thought that the price increases would be considered unfair by society, being largely viewed as an additional tax rather than a measure to reduce CO_2 emissions:

"People aren't concerned about the environment so they'd see this policy as an unfair tax increase" and *"People don't think they should pay more to use their cars because they can't see why it's wrong".*

5.6 Effectiveness

The perceived effectiveness (ability to meet emissions target) was rated on a 7-point scale ranging from 0 (completely ineffective) to 6 (completely effective). The average ratings, with standard deviations in brackets, are displayed in table 5.9.

Table 5.9 Perceived effectiveness

	TCP scheme	FPI
Personal rating	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 ($p<.005$). The perceived effectiveness of each policy emerged as a key aspect, underpinning the responses to several other questions. The most commonly stated reason for rating the TCP scheme as effective was the limit on carbon availability:

"If you can't go over the limit than it has to be successful" and *"The permit allocation would encourage people to stay within the limit"* and *"It'd make people think about what they were doing because you've got your own allowance with a figure on it"* 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"* and *"There'd be no extra costs if you stay within your limit".*

The FPI was considered to be much less effective with the majority of respondents feeling that the additional fuel costs would be absorbed by the majority, with costs needing to be much higher to incur change:

"People'd complain but they'd still pay the extra" and *"Putting the price up doesn't work. People don't stop smoking because the price goes up, they stop smoking for other reasons"* and *"It'd just be easier for most people to pay the extra cost and carry on rather than moving house or changing job"* and *"People would just reduce their spending on other things so they could carry on buying fuel"* and *"From my observations fuel price increases don't make any difference to consumption".*

5.7 Acceptability

Respondents were asked to rate their personal acceptability, and their perceived social acceptability of the TCP scheme and the fuel tax increases. Responses were given on a 7-point scale ranging from -3 (completely unacceptable) to 3 (completely acceptable). Table 5.10 displays the average ratings of acceptability for both policies.

Table 5.10 Personal and social acceptability

	TCP scheme	FPI
Personal rating	1.14* (1.59)	0.32 (1.82)
Social rating	- 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 personal acceptability ratings for the TCP scheme and the FPI were significantly different ($p<.01$), as were the social acceptability ratings ($p<.005$).

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.

In relation to the TCP scheme, the most commonly stated reasons regarding acceptability were the benefits received:

"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".

Conversely, for the FPI the most common jointly stated reasons were the monetary cost and unfairness:

"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" 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"* and *"There'd be no benefit or change therefore it wouldn't achieve anything which makes it unfair".*

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".

6. Conclusions and implications for policy makers

This research used innovative techniques to provide the first set of empirical data regarding public response to a personal carbon trading scheme. In addition, this paper contributes to the growing debate on the use of trading versus taxing measures by reporting a detailed survey of the public response to two purposefully designed policies – a Tradable Carbon Permit scheme and a system of fuel price increases. Whilst the sample was small and biased towards high education levels, high concern for the environment and above average incomes, 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. Whilst it is possible that the results could vary amongst a sample exhibiting different characteristics to those reported here, it is logical to assume that people would be more willing to support an effective policy.

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. This highlights the difficulty of making an FPI effective whilst also being acceptable. 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.

During the survey a number of respondents felt that the limit on carbon availability and use of carbon permits would constantly remind them of the purpose of the scheme and suggested that the TCP scheme could resultantly 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 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. 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.

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. Overall, the results strongly support further investigation into the application of tradable permits to reduce emissions from personal road transport. As noted by respondents, 'something needs to be done', and it is highly possible that a TP scheme could play a crucial role.

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