Public Acceptability of Personal Carbon Trading and Carbon Tax

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Abstract

Climate change is one of the greatest challenges confronting the international community requiring action to achieve deep cuts in carbon emissions. The implementation of potentially uncomfortable but necessary policy measures is, though, critically dependent upon public acceptability. This paper reports a novel application of stated preference techniques to explore the influence of key design attributes on the acceptability of a personal carbon trading scheme in isolation and when compared to a carbon tax. Illustrative forecasts from the models developed indicate the importance of design attributes, especially the basis of the initial permit allocation for personal carbon trading and the use to

which revenues are put for carbon tax. Results indicate that the “best” scheme designs could be acceptable to a majority of respondents.

Keywords: Personal carbon trading, carbon tax, stated preference, public acceptability.

1. Introduction

In the light of compelling evidence of the need to make very deep cuts in greenhouse gas emissions (IPCC, 2007; Stern, 2006), the UK Government has committed to an 80% cut by 2050 relative to 1990 levels (Climate Change Act, 2008). Transport and domestic energy are the only sectors where emissions in 2006 exceeded those of 1990 (DECC/Defra, 2009) and together personal transport and domestic energy account for 42% of UK CO_2 emissions (DTI, 2007). This scenario is typical of the challenges facing many developed countries.

Personal Carbon Trading (PCT) offers a potentially powerful and innovative instrument with which to achieve demanding reductions in carbon emissions and has aroused interest at national government level in the UK (Defra, 2008a). PCT is a downstream trading mechanism normally understood to involve an initial allocation of carbon permits to individuals based on carbon reduction targets, with individuals able to buy and sell permits according to their desired carbon consumption and prevailing permit prices. However, the precise structure of a scheme could vary considerably given the potential range of additional design features including management of individual carbon accounts, market operation, regulation, permit allocation, scope of coverage and transaction costs. Policy makers would be interested in which scheme designs have the greatest acceptability amongst the general public.

PCT's natural downstream comparator policy instrument is the conceptually familiar Carbon Tax (CT) applied to consumer products. In accordance with Weitzman (1974), tradable permits and taxes are theoretically equivalent in terms of both efficiency and effectiveness. It is better to fix the price through a tax where there is uncertainty over the cost function and to fix the quantity through a tradable system when there is uncertainty over the damage function (Montero, 2002; Pizer, 2002). Recent work on trading and tax has looked at political economy aspects and concentrated on welfare effects and political acceptability (e.g. Babiker et al., 2003; Brannlund and Nordstrom, 2004; Crals and Vereeck; 2005, Dinan and Rogers; 2002, Parry and Small, 2005; Pezzey, 2003; West and Williams, 2004). The use of collected revenues and the way permits are allocated have been identified as the main determinants of distributional impacts and consequent political acceptability[1].

In the specific case of personal transport and domestic energy usage the theoretical case for permits over tax might then depend upon: the presence of a steep damage function where the costs of error are high, relative sensitivity to price and quantity signals, heterogeneity amongst consumers and the relative acceptability of different measures (Raux, 2008).

In the context of climate change the damage function is uncertain and potentially steep with high costs of missing abatement targets; price elasticities of demand for both vehicle fuel and domestic energy are low (Baranzini et al., 2000; Brons et al., 2008, Dimitropoulos et al., 2005). There is

[1] For a complete account of theoretical differences and equivalence between the two schemes please see Pezzey (2003) and Crals and Vereeck (2005)

a high degree of variation in emissions levels within as well as between countries (Brand and Boardman, 2006; Druckman and Jackson, 2008; Ermoliev et al., 2000). All these aspects combine to push the arguments towards tradable permits. Whilst the set up, administration and management costs of such a scheme are anticipated to be high, they might be expected to fall over time as in the case of road user charging systems (Raux, 2008), but are still likely to be higher than the costs of implementing a CT. The arguments in favour of CT generally focus on the clarity of the price signal, the ease of implementation and the generation and use of revenues for distributional purposes (Baranzini et al., 2000).

Individual involvement in environmental policy has been advocated in various recent studies (Ahlheim and Schneider, 2002; Israel, 2007; Malueg and Yates, 2006; Rousse, 2008; Shammin and Bullard, 2009). A PCT scheme appears to have the potential to target individually generated carbon emissions by taking into account source heterogeneity and providing visibility to fuel and energy consumption.

However, whilst theory might provide some insights into the attractiveness of PCT and CT, it is ultimately personal preference that determines their acceptability and the impact of specific scheme features on this acceptability. Some PCT scheme designs might be regarded as fairer (for example, with respect to the way permits are allocated) and allowing more personal choice (for example, the ability to bank permits for the future or retire them) but at the

106 expense of lesser privacy and being administratively more burdensome.
107 Perceived effectiveness might also influence acceptability.
108
109 These are empirical questions that this novel research seeks to answer
110 through the application of Stated Preference (SP) methods in what, as far as
111 we are aware, is the first study of its kind. We note that the statement of
112 Roberts and Thumin (2006) that "little study (if any) appears to have been
113 devoted to exploring more fundamental questions such as the basis on which
114 the public might judge the acceptability of a scheme" has since been echoed
115 by the UK Environmental Audit Committee (House of Commons, 2008a) and
116 Kerr and Battye (2008).
117
118 **2. Experience to date**
119
120 Researchers have examined the potential for the introduction of tradable
121 permits in the transport and/or domestic energy sectors and in some cases
122 economy wide (Defra, 2008a; Dresner and Ekins, 2004; Fleming 2005;
123 Harwatt, 2008; Hillman, 2004; Niemeier et al., 2008; Raux, 2008; Starkey and
124 Anderson, 2005; Verhoef et al., 1997; Wadud et al., 2008; Zanni and Bristow,
125 2009). These studies have focused on theory, implementation, distributional
126 effects, scheme design and to a lesser extent behavioural response.
127
128 A small but growing number of studies, largely in the UK, have addressed the
129 acceptability of PCT and in some cases CT (Bird et al., 2009; Capstick and
130 Lewis 2009; Energy Saving Trust, 2007; Harwatt, 2008; Howell, 2008; Jagers

et al., 2009; Owen et al., 2008; Von Knobelsdorff, 2008; Wallace, 2009, YouGov, 2006a and 2006b). Approaches vary from highly qualitative focus groups and in-depth interviews to postal and internet surveys and national polls. Support for PCT lies in the range 25 to 47%[2]. Most of these studies do not use hypothecation or revenue recycling in the CT option nor do they mention the higher costs of PCT. Nevertheless, this level of expressed support for what is after all a very unfamiliar idea provides a promising base from which to explore acceptability. Polling evidence suggests that support for green taxes increases with hypothecation of revenues, especially if directed to tax cuts and environmental or energy expenditures, when support can exceed 70% (BBC, 2007; Green Fiscal Commission, 2007; Ipsos Mori, 2006; YouGov, 2006c). However, most work to date on the acceptability of PCT or CT has asked for responses to fixed designs. No studies to date have systematically explored the impact of varying design features on acceptability.

It therefore seems sensible to draw from and build upon the experience accumulated over many years from studies of public acceptability of road user charging schemes (Jaensirisak et al., 2005). Here the key lesson is that SP methods are highly suitable, since 'policy packages' can be composed as a selection of clearly specified, relevant scheme attributes whose levels are varied in a controlled manner to allow, through appropriate statistical analysis, the estimation of how the different levels of each of the scheme attributes influence overall acceptability.

[2] This excludes two highly qualitative pieces, with non-representative samples that report very high levels of support at 77% and 91% and a national poll with 61% support where the question was perhaps not sufficiently representative of PCT.

3. Survey design

We here provide a brief description of the SP method which involves a series of choices between two hypothetical PCT scenarios or hypothetical PCT and CT scenarios, and then we set out the attributes and levels used to characterise PCT and the CT within these SP experiments and the reasons for their selection. We then detail the experimental design. The initial scheme descriptions presented to respondents are shown in Appendix A.

3.1 SP Methods

SP experiments offer respondents a series of hypothetical scenarios each made up of two or more options. In turn, these options are composed of relevant attributes and the evaluation of the options, by the respondent expressing a preference for one option over the other(s), indicates the importance attached to each attribute. The statistical analysis of the responses supplied serves two broad purposes. It reveals the utility weight attached to each attribute, which is central to decisions relating to product design and willingness to pay, and it underpins the forecasting of behavioural response to new products or amended designs and prices.

SP methods can take the form of ranking, rating or choice exercises, with the latter now dominating and typically offering between 8 and 12 choices between two options each characterised by between 3 and 5 attributes. Their background lies in marketing research and over the past 40 years there has been extensive application to consumer goods and services in a wide range of

market settings, with increasing application in recent years to non-traded products such as environmental goods and general 'quality of life' factors. We are here interested in its novel application to non-market products, in this context relating to policy measures which were also the subject of early applications (Donnelly et al, 1976; Eberts and Koeppel, 1977; Hoinville, 1971). However, we are not aware of any previous application of SP to assess the acceptability of PCT or CT schemes.

3.2 PCT design attributes

Some elements of scheme design were fixed, including the free annual carbon allowance of 4 tonnes of CO_2 per person, similar to the actual average level of 4.25 tonnes (DTI, 2007). All respondents completed the "ACT on CO_2" carbon calculator (Defra, 2007a) to estimate their emissions from domestic energy and transport[3]. Thus all respondents were aware of their starting point with respect to emissions and hence the impact of the proposed scheme on them personally.

The attributes and levels selected to compose PCT schemes, with the wording used in the survey, are given in Table 1. Note that in many cases we have no a priori expectations of the relative importance of the different attribute levels due to the novelty of the schemes and since individuals' circumstances vary as will the extent to which individual or social considerations might influence preferences. In determining the levels for different attributes we sought to capture the range of proposals in the

[3] The carbon calculator does not include bus, rail or tram emissions, but as these amount to only 2% of total transport emissions this was an acceptable limitation.

literature and in some cases to offer more extreme variants to generate a wide range of attribute levels and responses.

Table 1 about here

Permit Allocation: An equal per capita allowance gives an equal right to pollute or responsibility not to and lies behind the contraction and convergence approach to reducing global emissions (Royal Commission on Environmental Pollution, 2000). There is continuing debate as to whether parents should receive additional permits for their children (Dresner and Ekins, 2004; Hillman 2004; Starkey and Anderson, 2005). We have specified an allocation that gives an equal allowance to all adults (AADULT), one that additionally provides a child allowance equal to that for adults (AINDCHILD) and one with a child allowance set at 40% of the adult allowance (AIND40). As an alternative to a per capita allowance, we have also included an equal allowance to each household (AHOUSE).

Permit allocation to industry through the European Trading System has reflected historic emissions (Ellerman and Buchner, 2007). An allocation based on current consumption (ACONS) was included to establish whether individual preferences recognise the 'rights' of high emitters (Seyfang et al., 2007).

Although a PCT scheme would be progressive in its overall impact, some lower income households would almost inevitably lose out (Thumin and White

2008), including those with higher energy needs through disability, poor housing or location relative to facilities. The principle of equal per capita allocation has been questioned partly on the grounds of unequal needs (Starkey, 2008). Equity is addressed here through higher allocations (AEXTNEED) or financial support (AFINNEED) to those with greater need and an allocation based on Government assessment of need (AGOVT). These levels are used to assess whether there is a difference in the acceptability of financial (AFINNEED) and effectively in-kind support (AEXTNEED). The acceptability of AGOVT may be different for two possible reasons. Firstly, respondents may think that a Government assessment of need would not align with that described under AEXTNEED and AFINNEED and might be politically determined. Secondly, the response may vary simply because of distrust of Government.

Excess Permits: An emerging issue from qualitative work is that some low emitters would rather keep or retire permits than let high emitters have them (Harwatt, 2008; Prescott, 2007). In general, we might expect individuals with excess permits to prefer to have choices on the disposal of permits rather than to have forced trading.

Thus the levels specified include two with an implied degree of forced participation whereby permits must be sold in the market (EMKT) or must be sold in the market or donated to charity (EMKTCHY). The other levels allow for private sales (EPRIV) or provide a choice between selling, donation and destruction (ECHOOSE).

Permit life: Individuals may wish to save (bank) permits or have permits with longer life to maximise long run utility and cover planned future events, such as long haul flights, or unexpected events. However, some respondents might see this as undermining the effectiveness of the scheme.

Two levels of permit life of one year (P1) and 5 years (P5) exclude banking. The remaining two levels both have a one year lifetime and one allows up to 50% of permits to be banked for 5 years (P1_50) and the other up to 25% to be banked for 10 years (P1_25).

Purchase Limits: Some might favour limiting permit purchases in order to avoid excess personal use of carbon (Bird et al., 2009) and possibly protecting against speculation. Others might regard any restriction as an excessive constraint on their quality of life or freedom.

One level allows unlimited purchases (LNONE) and three levels allow the purchase of increasing amounts from a quarter (L1/4) through a half (L1/2) up to the amount of the original equal allowance (LSAME).

Scope of the Scheme: A scheme could cover all energy consumption in the home and personal transport including travel by car, air, and public transport modes[4]. We might expect some to have a preference for a broader scheme,

[4] Embodied emissions are not included.

as it would offer more options for CO_2 reduction. However, others might prefer modes of transport they use extensively to be omitted.

Scope has three levels, covering domestic energy and all modes of transport (SALL), domestic energy, car use and air travel (SHCARAIR) and domestic energy and car use only (SHCAR).

Transactions: A PCT scheme would involve the exchange of both money and carbon for goods or services. Two levels are defined, firstly, a simple pay as you go transaction where carbon is automatically deducted (TAUTO), and secondly, (TADD) which requires two transactions to be made. Some might prefer a dual transaction for reasons of trust, risk of fraud or a desire for carbon consumption monitoring whilst others might prefer the ease of a single transaction.

Management of Carbon Accounts: This attribute was included to explore issues of trust and efficiency (Dresner et al., 2006; Hsu et al., 2008). The levels include two single operator options; a Central Government agency (MGOVT) and a national not for profit operator (MNAT). The remaining levels each offer some choice; a combination of a national not for profit operator and banks (MNATBANK[5]), a Central Government Agency and local organisations (MGOVTLOC), and an open market where any suitable operator may offer carbon accounts (MANY).

[5] Note that the survey took place prior to the 2008/9 banking crisis.

Market Operation: Prices could be established by the free market (OMKT) or with a government set ceiling (OMKTCEIL), or could be fixed by government (OGOVT) as in the initial phase of the CRC Energy Efficiency Scheme (Environment Agency et al., 2010). We might expect a preference for a regulated price to avoid the possibility of very high prices, especially by the risk averse and those on low incomes who do not always have low emissions (Dresner and Ekins 2004), although again questions of trust and also economic or political belief may influence responses.

Permit Price: The permit price range encompasses recent prices of CO_2 per tonne (in 2008 prices) of £42.61 from the Stern Review (Stern, 2006), the £26 UK Government shadow price (Defra, 2007b), the new mitigation based central non-traded sector value of £50 (DECC, 2009) and £19.90 as the European Trading System trading price (pointcarbon.com, 24th July, 2008). The higher levels cover the expected low price elasticity of demand for fossil fuels, and the Wadud et al. (2008) finding that a $500 per tonne CO_2 price would only reduce gasoline consumption in the USA by 15%, whilst the lower prices were included to assess whether they were critical to acceptability.

The set up and running costs of a PCT scheme are not explicitly included due to uncertainty around available cost estimates (defra 2008b; Lockwood 2009). However, the range of the price attribute is such that the influence on acceptability of set up and running costs over and above those of a CT may be explored in the appraisal of the schemes through the price of carbon.

3.3 CT attributes

The attributes and levels used to represent CT schemes are listed in Table 2.

Table 2 about here

How the tax works: In contrast to PCT, a CT raises revenue and the use to which this is put is likely to influence acceptability. Two of our levels have been used in other studies of PCT; RGEN denotes the option of no hypothecation, the default of the UK tax system (Bird et al., 2009), and RCHANGE represents the use of revenues to facilitate changes in behaviour (Harwatt, 2008). Owen et al., (2008) proposed that all tax revenue be recycled back to users on an equal per capita basis, here we use a variant of this approach to "mimic" the functioning of the PCT, by giving individuals an amount of money equal to the tax paid on carbon up to 4 tonnes (RLUMP). This is similar to the CT with tax credit proposed by Read and reported by Cohen and Vandenburgh (2008). RTHRESH sets a personal allowance (similar to an income tax threshold) such that the tax is only paid on consumption above the allowance, similar to the proposal by Metcalf (2009) for a CT with a capped income tax credit in the United States.

The remaining levels recycle the revenues through spending on technological solutions (RTECH), cuts in income tax (RINC) or cuts in local taxes (RCOUNCIL).

Tax Rate: The tax rates were set between £5 and £250 per tonne of CO_2, largely in line with the PCT permit prices.

3.4 Stated Preference exercises

Two generic SP exercises were designed each of which required respondents to evaluate two options. One exercise specified these to be different PCT schemes (PCT_A and PCT_B) whilst in the other exercise the two options involved a comparison of PCT and CT schemes. This overall configuration places more emphasis on PCT as there are more PCT attributes to cover. Table 3 shows the two options in each SP exercise, the attributes used to describe each option and the various levels that each of these attributes could take.

Given the large number of PCT attributes, and their unfamiliarity to respondents, they were split between two PCT specific exercises, denoted SP1 and SP2 in Table 3, and these cover eight of the nine PCT attributes. Permit price and allocation method were common due to their hypothesised importance. In order to simplify the evaluations, the three specific attributes (i.e., those other than price and allocation) were only varied in one of the options. For each attribute one level is common to the two options and serves as the base in the analysis.

The two exercises comparing PCT and CT are termed SP3 and SP4. Here the PCT options are characterised by the same attributes as in SP1 and SP2

respectively, except that in SP3 scope replaces the transactions of SP1 so that all nine PCT attributes are covered across the four SP exercises.

The sample choice cards in Appendix B show that respondents expressed a preference between the two options and indicated the acceptability of each option.

Table 3 about here

4. Data Collection and Characteristics

The survey was implemented in two phases. Firstly, at a Citizens Forum in Cardiff in January 2008 involving 79 respondents recruited locally to be broadly representative of the Energy Saving Trust market segmentations in order to capture a diverse range of lifestyles and opinions (RSA, 2008). Secondly, a survey in the South East of England involving 208 respondents with on-street recruitment where people were asked to participate in a survey about climate change of around 45 minutes duration and offered £10 as an incentive to participate. Interviewers were asked to recruit respondents to achieve a spread of gender, employment type, age group and car ownership. The average carbon footprint was 5.6 tonnes CO_2 split roughly 40% transport and 60% domestic energy use. During the interview, which also covered socio-economic characteristics, attitudes and behaviours, each respondent completed two separate SP exercises, one PCT v PCT and one PCT v CT.

For each exercise they were asked to look at 6 or 7 pairs of choice cards (see Appendix B for examples).

The sample was fairly evenly split 52% male and 47% female (1% missing). There is also a good representation across the age groups of 18 to 29 years (24%), 30 to 44 years (30%), 45 to 60 years (24%) and over 60 (21%), with again 1% missing data. Unfortunately, 22% respondents did not disclose their income group, and therefore in the analysis employment status is a crude proxy for income. The average household size is 2.7 with just over half the respondents living in adult only households. About half the sample live in their own homes with the rest renting or living with their family. More than half the sample were employed full or part time. 32% of respondents are in non-car owning households, somewhat above the national average of 24% (Department for Transport, 2008). This was intentional, as car ownership was the only easily available screening question to yield an indication of carbon footprint and clearly we needed to recruit respondents both below and above our permit threshold.

5. Analysis

5.1 Model structure

By far the most common method used to explain discrete or categorical SP data is the multinomial logit model. It is assumed that each agent i chooses that option from the n on offer which yields maximum utility (U) or satisfaction. Thus option 1 is chosen if:

$$U_{i1} > U_{in} \quad for\ all\ n, n \neq 1 \tag{1}$$

In turn, the overall utility for each option is made up of the part-worth utilities associated with a range of explanatory variables. An error term (ε_i) is introduced to represent the net effect of unobserved influences on an individual's choices. Hence individual i bases decision making on what might be termed random utility which for option 1 (U_{i1}) is made up as:

$$U_{i1} = V_{i1} + \varepsilon_{i1} \tag{2}$$

V_{i1} is the deterministic part of utility which can be related to those attributes (X_k), such as those characterising the SP options, which can be observed and measured. This could be represented as:

$$V_{i1} = \sum_{k=1}^{K} \alpha_k X_{ki1} \tag{3}$$

The utility functions for other options are specified in an entirely analogous fashion. As analysts, by definition we can proceed only by observation of V, yet this ignores the influence of what is to us unobservable. We cannot be sure that option 1 is preferred if V_{i1} is the highest, yet the analysis must proceed on the basis of this observable component of utility alone.

The way forward is to specify the problem as one of explaining the probability of an individual choosing a particular option. We would expect the likelihood of choosing option 1 to increase as its overall random utility increases. The probability that an individual chooses option 1 (P_{i1}) from the n on offer can be represented as:

$$P_{i1} = \Pr\left[\left(V_{i1} + \varepsilon_{i1}\right) > \left(V_{in} + \varepsilon_{in}\right)\right] \quad for\ all\ n, n \neq 1 \tag{4}$$

By assuming some probability distribution for the ε_{in}, the probability of choosing option 1 can be specified solely as a function of the observable component of utility. Assuming that the errors associated with each option have a type I extreme value distribution and are independently and identically distributed yields the familiar multinomial logit model (MNL):

$$P_{i1} = \frac{e^{V_{i1}}}{\sum_{j=1}^{n} e^{Vij}} \tag{5}$$

The coefficients of the logit model's utility functions are estimated by maximum likelihood to provide the best explanation of individuals' discrete choices and denote the relative importance of the attributes. We will have expectations as to the sign of the coefficient estimates. However, the absolute magnitudes of the coefficients have no meaning since they are estimated in units of residual variation. The more random error there is in the SP data and the larger the error variance, then the smaller the coefficient estimates. This

scaling does not impact on the relative importance of the coefficient estimates, since it applies equally to all coefficients, but it will impact on the use of equation 5 in forecasting mode and the greater the amount of random error and lower scale then the forecast choice probabilities will tend towards what are equal shares across the available options.

There are two key dimensions to cater for in modelling. At one level, we have four SP variants, with different attributes and indeed choice contexts as is apparent in Table 3. We also have two response scales; one relating to the preference between option 1 and option 2 in Table 3 and the other a five-point acceptability rating of option 1 and option 2 separately both as depicted in Appendix B.

One way forward would be to estimate four separate models for each of the SP variants dealing with preferences and additionally eight separate models of the acceptability of each of the options (6 PCT and 2 CT) in Table 3. However, this is not parsimonious and, moreover, would inevitably lead to different results for the same attributes across the different models.

A better approach is to pool the data across the SP variants and the two response scales. However, such an approach needs to recognise that the separate data sets will have different amounts of random error, due to different degrees of attribute familiarity and difficulty and different response scales and choice context. Given that the coefficients of logit models are scaled inversely to the amount of random error, not to account for different

494 error variances across data sets could spuriously transmit an effect to an
495 attribute that was actually due to different scale.
496
497 The models were estimated using BIOGEME (Bierlaire, 2003). It contains an
498 estimation procedure whereby a data set is selected as the 'base', implicitly
499 with a scale of one, and the utility functions relating to all other data sets have
500 an associated parameter to allow for a possibly different scale (Hess et al.,
501 2008).
502
503 Each respondent yields three pieces of information per scenario; two
504 acceptability responses and one preference. We modelled the responses as a
505 simple binary logit. We could have instead modelled the acceptability
506 responses as a multinomial logit, with five options covering the range of
507 permissible responses. However, the binary model is preferred as we are
508 ultimately interested in predicting whether a scheme is acceptable or not.
509 Indeed, the independence of irrelevant alternatives property of multinomial
510 logit would cause problems in forecasting acceptability since it would force, for
511 example, the 'cross-elasticity' between definitely acceptable and moderately
512 acceptable to be the same as that between definitely acceptable and definitely
513 unacceptable when in fact there would be more 'competition' between the
514 former than the latter pair.
515
516 Conflating the five point scale to binary ignored the distinction between the
517 definite and moderate categories and lost 1062 observations relating to the
518 neither acceptable nor unacceptable category. Option 1 in the binary logit

519 model denotes acceptable, and its utility is composed of the attributes used to
520 characterise either the PCT or CT scheme, and option 2 represents
521 unacceptable, with utility of zero. With regard to the preference data, option 1
522 (2) was the PCT (CT) option. The pooled model contains eleven binary choice
523 contexts covering: six PCT acceptability scenarios; two PCT preference
524 scenarios; two PCT and CT preferences; and one dealing with the two
525 identical CT acceptability scenarios. In doing this pooling, we are not
526 unreasonably assuming that the weights attached to each attribute in relative
527 terms are the same in the acceptability and preference data, but we are
528 allowing their absolute magnitude to vary in line with scale differences.
529
530 Inspection of the pooled model indicated that, as might be expected, the
531 scales for the seven acceptability models were generally similar. Given that
532 different scales would be inconvenient for forecasting, all were constrained to
533 be the same. Once this was done, the remaining four scales, covering the
534 preferences, were each insignificantly different from one. Hence we can
535 remove the need to specify different scales.
536
537 **5.2 Pooled Model**
538 The estimated models are reported in Table 4. All attributes other than cost
539 are represented by dummy variables and their coefficients are interpreted
540 relative to the clearly denoted base attribute level that is common to both
541 options.
542

543 The models are estimated to 8731 choice observations covering 287
544 individuals. We eliminated 1422 observations because the screen displaying
545 the first set of SP scenarios in Cardiff was not clearly visible to all
546 respondents, 1456 no preference and non responses and 256 observations
547 because of a mistake in some options presented.
548
549 Model I contains all attribute levels. However, our preference is for Model II
550 which removes the 21 coefficients that were not significant at the 10% level
551 and which generally have very low t ratios and little impact on the SP
552 responses. We would not expect all to have a significantly different effect to
553 their base and the removal of these insignificant coefficients increases the
554 precision of the remaining coefficients whilst generally having only a minor
555 impact on their magnitude. Most of those retained are significant at the 5%
556 level. The goodness of fit is low and no doubt the completely unknown choice
557 contexts and unfamiliar attributes presented here will have contributed to this.
558 The discussion below is based on Model II.
559
560 **Table 4 about here**
561
562 Permit Allocation: Four levels were insignificantly different from the base
563 (AINDCHILD), and it is credible that respondents regard these as broadly
564 upholding the general principle of a fair allocation. Nevertheless this includes
565 an allocation based on current consumption (ACONS) where it may be that
566 selfishness prevails or respondents see consumption as reflecting needs.
567

Whilst there is no support for financial assistance for those in greater need (AFINNEED), there is a preference for support through allocating extra permits (AEXTNEED). This may be because it is in-kind support targeted at a recognised consumption need. Qualitative research on PCT also found support for extra help for vulnerable groups (Bird et al., 2009; Owen et al., 2008) and research on greenhouse gas reduction policies identified support for discounts to low income households (Dietz and Atkinson, 2009).

Removing the allocation to children entirely (AADULT) reduces acceptability, presumably on the grounds of fairness and for some respondents, vested interest. Bird et al. (2009) and Owen et al., (2008) also found support for an allowance to children. The most unacceptable allocation is according to a government assessment of need (AGOVT). This is despite the preference for extra permits for those in greater need but is in line with objections to means testing identified by Owen et al. (2008).

Excess Permits: The base is the option that gives respondents the greatest choice in the disposal of excess permits; they may be sold, donated or destroyed (ECHOOSE). EPRIV is similarly liberal and it is therefore not surprising that it is not significant. The two levels where some restrictions are placed on disposal are regarded to be inferior, which is to be expected.

Permit Life: The opportunity to be able to bank 25% for up to 10 years (P1_25) was not deemed attractive relative to the base of a one year permit life and no opportunity to bank (P1). However, there is a preference for being

593 able to bank 50% for 5 years (P1_50). Only half as strong was the preference
594 for permits remaining valid for 5 years (P5). This might suggest that
595 respondents feel that long permit life could undermine the effectiveness of the
596 scheme. Whilst this would not be a correct interpretation in a properly
597 designed scheme with a cap, here and elsewhere, we are interested in
598 respondents' perceptions of the schemes not whether those perceptions are
599 right or wrong.
600
601 Purchase Limits: The base level is the most permissive, allowing respondents
602 to purchase as many permits as they wish (LNONE). Acceptability would be
603 increased by introducing a restriction, with a preference for allowing the
604 purchase of permits up to the original allocation (LSAME). Whilst L1/4 and
605 L1/2 were not significant, this is perhaps unsurprising given that their effects
606 would be expected to be less than LSAME whose t ratio was not large. It
607 seems that respondents see the need for some limits for at least two possible
608 reasons (Harwatt, 2008; Owen et al., 2008): firstly, a perception that the
609 system will not work in the absence of limits; secondly, a general reluctance to
610 let high emitters 'buy their way out'.
611
612 Scope of the Scheme: The base defines the scope of the scheme very
613 broadly to include not only domestic energy, car and air transport but also
614 public transport (SALL). No significant effects could be discerned for the two
615 variations from this base. Bird et al. (2009) found mixed views on the inclusion
616 of both aviation and public transport, which suggests that our results are not
617 unreasonable in finding no clear preference.

Transactions: No significant difference could be discerned between the base of automatic updating of carbon accounts (TAUTO) and a system where carbon movements needed to be authorised (TADD). This is perhaps surprising; the pay as you go option was preferred in focus groups conducted by Owen et al. (2008).

Management of Carbon Accounts: One option (MGOVTLOC) is not significantly different from the base of management solely by a Government Agency (MGOVT), implying that a local organisation adds little or no benefit.

A single not for profit operator (MNAT) is more acceptable than government management whilst adding in high street banks strengthens this (MNATBANK). An open market (MANY) is preferred to management by government agency. Whilst, Owen et al. (2008) found that scepticism surrounding Government's ability to run such a scheme was outweighed by objections to private operation and profit taking, in this case distrust of Government seems to prevail.

Market Operation: The base allows permit price to be determined by a free market (OMKT) and is not significantly different from a market determined price with a Government set price ceiling (OMKTCEIL). However there is a preference for Government to set prices on an annual basis (OGOVT). This may reflect a preference for price certainty alongside an expectation that a Government price might be lower.

How the Tax Works: The base level was set at all carbon consumption is taxed and the revenue raised is used to reduce local council tax (RCOUNCIL). Three other options which also tax all carbon consumption but use the revenues to cut income tax (RINC), provide a lump sum amount of money (RLUMP) and stimulate energy efficiency (RTECH) were all insignificantly different. This is perhaps unsurprising. On the other hand, a scheme would be less acceptable if all carbon consumption was taxed and revenues simply went into the general tax budget (RGEN). This preference for hypothecation is in line with the overwhelming findings regarding public acceptability of road user pricing (Jaensirisak et al., 2005).

There is, however, a strong preference for an exemption from the tax up to the 4 tonnes threshold (RTHRESH). This is preferred to RLUMP even though the latter would give a greater benefit to low carbon users and the two schemes would be the same for high carbon users. It may be that exemption thresholds are a familiar concept and perceived to be efficient due to their ease of application, whereas some might not believe that the government would make lump sum payments. Using the carbon tax revenues to make it easier to change behaviour and reduce consumption of carbon (RCHANGE) was also strongly favoured over their use for financial compensation. Interestingly, Dresner et al. (2006) and IPSOS MORI (2006) found stronger support for taxation of energy and aviation respectively where revenues were recycled into environmental expenditures rather than tax cuts.

668 Permit Price / Tax Rate: The cost attributes represent the total cost that would
669 be incurred given the permit price or the carbon tax rate and each individual's
670 carbon footprint. We specified separate cost attributes for those consuming
671 over 4 tonnes who have to purchase permits to support the excess
672 consumption ($CostPCT_H$) and the remainder who can sell permits ($CostPCT_L$)
673 where a positive coefficient is expected.
674
675 The specification of the total cost under CT (CostCT) proceeds similarly. All
676 carbon is taxed except when the 'how tax works' attribute takes the level
677 RTHRESH, whereupon the tax applies only to consumption above the 4
678 tonnes threshold. When the 'how the tax works' attribute takes the level
679 RLUMP, there is a lump sum payment equal to 4 times the tax rate. Thus
680 those whose carbon footprint is lower than 4 tonnes will gain and we define a
681 cost term ($CostCT_G$) with an expected positive coefficient.
682
683 The coefficient estimates where respondents gain financially were both
684 insignificant. This is not surprising in the context of CT since the lump sum
685 payment occurs only a few times. In general, Owen et al. (2008) noted that
686 respondents focused on costs and were less likely to discuss gains even
687 when these were explicitly pointed out to them. Insignificant cost coefficients
688 on reductions in local tax/utility bills have been found in other SP experiments
689 (Wardman and Bristow, 2008; Lanz et al., 2009). Whilst commonly attributed
690 to loss aversion, it could also be due to a lack of trust that the reduction would
691 materialise.
692

693 For those who would pay, the cost coefficients are amongst the most precisely
694 estimated. CostCT exceeds $CostPCT_H$ and this may reflect respondents'
695 greater familiarity with a tax instrument and/or a higher level of expectation
696 that a tax might be implemented. In addition, there is the opportunity for some
697 under PCT to change behaviour so as to be permit sellers rather than buyers
698 and this would operate to reduce the $CostPCT_H$ coefficient[6].
699
700 Alternative Specific Constants (ASCs): Such constants discern the net effect
701 on utility of unobserved variables, such as, say, basic attitudes toward PCT[7]
702 or CT all else equal, as well as the utility associated with the base levels of the
703 categorical variables. ASCs were specified for PCT and CT and also options
704 with different common base categories. Four ASCs were statistically
705 significant covering the acceptability of the two PCT options in SP1 (ASC1),
706 the PCT options in SP2 and SP4 (ASC2), the PCT option in SP3 (ASC3) and
707 CT in SP3 and SP4 (ASC4).
708
709 ASC1 denotes that together the base levels of AINDCHILD, P1, TAUTO and
710 MGOVT reduce acceptability. This is also the case for AINDCHILD, P1, SALL
711 and MGOVT in ASC3. It would seem that the widespread scope of the
712 scheme (SALL) contributes much more to unacceptability than does the
713 automatic updating of carbon accounts (TAUTO). This seems credible.
714

[6] Data on potential behavioural response was available from the survey. However, the use of this "post implementation" data did not improve the models.
[7] This could include any views respondents might have on the additional set up and administration costs of a PCT scheme.

ASC2 increases acceptability and covers the base categories of AINDCHILD, LNONE, OMKT and ECHOOSE. Whilst OMKT would be expected to be unattractive, the other two levels are the most permissive and hence offset the latter.

ASC4 covers the base CT level of RCOUNCIL and, relative to the other ASCs, any inherent relative preference amongst CT and PCT. It also increases acceptability. This is perhaps unsurprising, since RCOUNCIL involves the recycling of all revenues.

Other issues: We allowed for systematic variation in parameters according to the socio-economic and carbon use characteristics of respondents by specifying interactions between these and the main effects. However, we were only able to obtain a very small number of intuitively expected and statistically significant effects. For example, households with children prefer allowances to include children and car users prefer more generous permit life and buying opportunities as did those with a low carbon footprint, this last being less expected. Even then, the magnitude of the incremental effects was minor. The level of precision with which the main parameters were estimated, to which the relatively small sample size and unfamiliar choice context contribute, is not conducive to discerning significant and strong socio-economic effects. Moreover it is important to remember that many attribute levels may be regarded positively or negatively depending on a respondent's attitudes and context, and this greater randomness will hamper efforts to

identify systematic effects. We experimented with random parameter specification on some coefficients (e.g. cost) but this was not successful.

5.3 Model Application

The model can be used to forecast how scheme composition may impact on acceptability. This provides insights not readily transparent from the results in Table 4 and which would also be of fundamental interest to policy makers confronted with policy design and presentation challenges.

We use the estimated logit model in 'forecasting mode' to determine the probability that a particular PCT or CT scenario is acceptable. In this binary case, the multinomial logit model of equation 5 simplifies to:

$$P_1 = \frac{1}{1+e^{V_2-V_1}} \tag{6}$$

The probability that the scenario is acceptable (P_1) is a function of the difference in the utility of option 1 and option 2. The utility of option 2 (V_2), as we have stated, is set to zero. The utility of option 1 (V_1) represents a particular set of attributes that compose a scenario along with the weights estimated for the relevant attributes and reported in Table 4. Taking the fourth scenario in Table 5, where the PCT scenario specifies allocation as AEXTNEED, the life of the permits as P1_50, scope as SALL, and the management as MNATBANK, and for a carbon footprint 1.6 tonnes in excess

763 of the allowance (CF-CA=1.6) with a permit price of £100 per tonne, the utility
764 function is:
765
766
$$V_1 = -0.962 + 0.350\,AEXTNEED + 0.301\,P1\_50 + 0.0\,SALL + 0.319\,MNATBANK - 0.000204\,(CF - CA)CostPCT_H = -0.025$$
767
768
769 which in equation 6 yields a probability of acceptability of 0.49. In other words,
770 49% of individuals if confronted with this situation would find it to be
771 acceptable.
772
773 Illustrative forecasts are presented in Table 5. The scenarios are based
774 around those actually offered in the SP exercise. These are for PCT as in SP3
775 (Scenarios 1-5), PCT as in SP2 and SP4 (Scenarios 6-12) and CT (Scenarios
776 13-16). We cover the base attributes and levels and the largest of any
777 significantly positive or negative variations from the base. Three price or tax
778 levels are used ranging from something close to the current price of carbon
779 (£25) to higher levels (£100 and £250). Four levels of carbon footprint (CF)
780 are examined relative to the carbon allowance (CA): 4 tonnes, where CF–CA
781 equals zero; 5.6 tonnes, which is our sample mean; a much higher level of 10
782 tonnes, given around 15% of our sample has a footprint at least this large; and
783 a mid-point of the latter two of 7.8 tonnes. Whilst we could have directly
784 evaluated PCT schemes relative to CT schemes, thereby obtaining a
785 probability that PCT is preferred over CT, the absolute acceptability
786 probabilities reported in Table 5 indicate the relative attractiveness of

particular PCT and CT schemes which would be sufficient for policy purposes in selecting a preferred scheme given that they are mutually exclusive.

Table 5 about here

What is immediately apparent from Table 5 is that the price of carbon has very little impact on the level of PCT acceptability. This is an intriguing finding; we might expect, and it is often observed, protest response towards increased financial outlay in SP models. Respondents had every opportunity to respond strategically to cost. Whilst the very hypothetical nature of the SP exercise might militate against such protest response, there is no obvious reason why respondents should systematically understate their sensitivity to permit price. The surprisingly low cost coefficient also implies little variation in PCT acceptability according to the level of carbon consumption, but note that we were unable to detect significant variations in other parameter estimates according the current level of carbon consumption. However, for CT we observe some large variations in acceptability, particularly amongst high carbon consumers, as the carbon tax varies.

There is a considerable amount of variation in acceptability according to scheme design, to the extent that CT can often be more acceptable than PCT for comparable financial cost (RTHRESH). However, PCT can be made more attractive than CT. Indeed, we observe that amongst our sample PCT and CT can each be politically acceptable.

PCT acceptability is seen to be critically dependent on the initial allocation of permits, where the move from worst (AGOVT) to best (AEXTNEED) can improve acceptability by over 25 percentage points. Here we find a preference not just for fairness in terms of an equal distribution but also one that reflects need. Other attributes also have a strong bearing on the acceptability of PCT. The highest levels of PCT acceptability, for scenario 9, reach 80%.

Similarly the acceptability of CT can vary by almost 20 percentage points according to how the tax works. The highest level of acceptability of CT, when there is a tax free threshold of 4 tonnes of carbon, as in scenario 14, is not far off 70%.

We can consider the potential additional set up and operational costs of a PCT over and above those of CT utilising the recent analysis by Lockwood (2009) who estimates an annual additional cost per person of approximately £50 based on defra central estimates and his own central estimate of £28. If we assume a tax of £50 for the CT based on the new cost of carbon (DECC, 2009) and a price per tonne of £78 to £100 for the PCT and compare acceptability, for the "best" designs and average carbon consumption, we find that the CT achieves 67% acceptance and the PCT 79% acceptance. This suggests that set up costs may not be a deal breaker for PCT. However, if these costs were outlined to respondents as set up and running costs we must recognise the possibility that the results could have been different.

6. Conclusions

This highly exploratory and novel study indicates that design has a critical influence on scheme acceptability for both PCT and CT. It follows that there is no unique preference for PCT relative to CT since it depends upon the features of the scheme.

Our findings indicate a preference for permit allocations that are fair where allocations that include children are preferred to those that do not and allocations with additional allowance for those with extra needs are preferred to those without. With respect to CT, preferences are for the revenue to be used for threshold exemptions or measures to facilitate change. These reflect findings elsewhere and thus increase our confidence in the findings with respect to less familiar attributes.

Our model predicts that the acceptability of PCT can reach 80% whilst that for CT can approximate 70%. This is without the PCT model being able to attribute a benefit to the 40% of our sample who would be in a position to sell permits, although we suspect that this benefit of PCT will have worked through into the other parameter estimates, particularly the constants, and that this will have contributed to the high acceptability of PCT.

A key result is that a PCT or CT can be politically acceptable. This is not as implausible as it first seems. Firstly, previous studies, admittedly with fixed designs, do evidence reasonable degrees of acceptability. Secondly, there are a large number of beneficiaries under our PCT scheme. Whilst this argument

862 does not apply to CT in general, that offered here aims to address serious
863 environmental challenges and typically returns the money raised which will
864 contribute to its popularity. Indeed, the CT fails to achieve 50% acceptability
865 when the tax revenue is not hypothecated.
866
867 Clearly, the issue of the public acceptability of measures that seriously
868 address individual carbon emissions is of considerable political interest, and
869 identifying the best scheme is critical for policy makers. Much further work
870 needs to be conducted to build upon what we believe is pioneering research.
871 Larger samples are needed to support more detailed analysis, particularly of
872 systematic and random taste variation, whilst means of improving the clarity
873 and range of scheme representation to finesse design and explore a wider
874 range of measures and their financial implications are required. There are a
875 range of aspects that we were not able to test systematically in this study,
876 including the impact on acceptability of the way the scheme is described and
877 explicit consideration of the influence of the setup and running costs of a PCT
878 scheme. The analysis might extend to involve an international dimension
879 whereby the acceptability of domestic policies is a function of international
880 actions.
881

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887

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APPENDIX A Description of the two schemes as they appeared to respondents

INTRODUCTION TO CARBON TAX

This would be a tax on all purchases of energy that contribute to climate change. This would include:

- Gas
- Electricity
- Petrol / diesel
- Heating oil, coal or wood.

This would increase the cost of all energy forms that contain carbon.

This higher price would reflect the cost to the environment and would make us think about:

- Conserving energy
- Changing what we do - installing or buying solar or wind power, using public transport instead of driving

Such a tax would generate money for the Government. This money could be used for a range of purposes:

- Reducing other taxes, such as income tax
- Investing in energy saving technologies or options, such as public transport or renewable energy.
- Measures to help individuals to change their behaviour or reduce consumption, home insulation grants, public transport etc.
- Give some money back to individuals directly.

TO SUM UP:

Everyone pays the same rate of tax regardless of income - in the same way as current purchase taxes.

The design could include lump sum payments, cuts in other taxes or expenditure on carbon reduction measures.

In this example we want you to consider that all carbon is taxed and the Government gives a tax refund up to the average carbon consumption. This means that only above average consumers pay more.

INTRODUCTION TO PERSONAL CARBON TRADING

The purchase and use of energy that contributes to climate change, gas, electricity, petrol /diesel, coal / oil / wood would require you to provide carbon permits for that amount of energy.

We are asking you to consider only your personal travel including commuting to a place of work but not business travel. Businesses would be subject to a similar scheme to encourage the reduction of emissions.

Allowance

All adults would be given an equal and free allowance of permits. Initially, in the first year this would be based on average carbon consumption. After that the allowance would gradually reduce to encourage reductions in carbon use.

Functioning

Every time you buy petrol /diesel or pay a gas or electricity bill the relevant number of permits would be deducted from your account.

If you do not have enough permits for a purchase you will need to buy additional ones

If you do not use all of your permit allowance you can sell them for money.

The principle is that people who need extra permits may buy them from people who have some in excess, and vice versa.

The aim would be to reduce emissions of carbon. A PCT (Personal Carbon Trading) would encourage people to do this to avoid having to buy permits or to allow them to sell spare permits.

We are now going to describe how a scheme might work and ask you about your response to it.

Adults would receive an equal allowance of 4.0 tonnes of CO_2.

Those with children would receive an additional, smaller allowance for each child under 18.

APPENDIX B Example Choice Cards from the two stated preference experiments

Choice Card 2		
ATTRIBUTE	Option 1	Option 2
Allocation of permits	equal allocation to all people including children	allocation to adults based on a government assessment of needs
Permit sale / purchase	£100 per tonne of CO_2	£50 per tonne of CO_2
Purchase limits	you may sell or buy as many permits as you like	purchases are limited to 1/4 of your local allocation
Price is set by	the market determines the price - no limits	the market determines the price - government sets a price ceiling
Excess permits	you can choose whether to sell excess permits in the market, donate or destroy them	you can choose whether to sell excess permits in the market, donate or destroy them

I would prefer	Option 1 ☐	Option 2 ☐

I find option 1				
Highly acceptable ☐	Moderately acceptable ☐	Neither acceptable nor unacceptable ☐	Moderately unacceptable ☐	Highly unacceptable ☐

I find option 2				
Highly acceptable ☐	Moderately acceptable ☐	Neither acceptable nor unacceptable ☐	Moderately unacceptable ☐	Highly unacceptable ☐

Choice Card 2			
ATTRIBUTE PCT	**Option 1**	**Option 2**	ATTRIBUTE TAX
Allocation of permits	equal allocation to all adults, children get 40% of adult allowance	all adults are given an exemption from the tax - up to the 4 tonnes CO_2, like an income tax threshold	*How the tax works*
Permit sale / purchase	£250 per tonne of CO_2	£10 per tonne of CO_2	*Cost per tonne CO_2*
An independent regulator oversees management of carbon accounts provided by:	a central government agency		
Lifetime of permits	permits expire after one year but 50% may be banked for up to 5 years		
Scope of the scheme	emissions from the home and all transport use: private car, public transport and air travel		
I would prefer	Option 1 ☐	Option 2 ☐	

I find Option 1				
Highly acceptable ☐	Moderately acceptable ☐	Neither acceptable nor unacceptable ☐	Moderately unacceptable ☐	Highly unacceptable ☐

I find Option 2				
Highly acceptable ☐	Moderately acceptable ☐	Neither acceptable nor unacceptable ☐	Moderately unacceptable ☐	Highly unacceptable ☐

1219 **Table 1: PCT Attributes and Levels**

Attributes and levels	Code
Permit Allocation	
Equal Allocation to all people including children	AINDCHILD
Equal Allocation to all adults, children get 40% of adult allowance	AIND40
Equal Allocation to all adults, no allocation to children	AADULT
Allocation according to current levels of consumption	ACONS
Equal allocation to all with extra permits for those with greater need, for example, living in rural area, poor housing or disability	AEXTNEED
Equal allocation to all households	AHOUSE
Allocation to adults based on a Government, assessment of needs	AGOVT
Equal allocation to all but additional financial support for those with greater need, for example, living in rural area, poor housing, disabilities	AFINNEED
Excess permits	
Excess permits must be sold in the market	EMKT
Excess permits may be sold privately to whoever you wish	EPRIV
Excess permits must be sold in the market or donated to charity	EMKTCHY
You can choose whether to sell excess permits in the market, donate or destroy them	ECHOOSE
Permit life	
All permits expire after 1 year	P1
All permits expire after 5 years	P5
Permits expire after 1 year but 50% may be banked for up to 5 years	P1_50
Permits expire after 1 year but 25% may be banked for up to 10 years	P1_25
Purchase Limits	
You may sell or buy as many permits as you like	LNONE
Purchases are limited to ¼ of your allocation	L1/4
Purchases are limited to ½ of your allocation	L1/2
You may purchase up to same amount of your original allocation	LSAME
Scope of the scheme	
Emissions from the home and all transport use, car, public transport and air travel	SALL
Emissions from the home and private car use only	SHCAR
Emissions from the home, private car and air transport.	SHCARAIR

Transactions	
Carbon account automatically updated, you do not need to do anything extra.	TAUTO
An additional transaction, you need to authorise any carbon movements in and out of account	TADD
An independent regulator oversees the management of carbon accounts provided by:	
A Central Government agency	MGOVT
A single not for profit organisation	MNAT
A single not for profit organisation and high street banks	MNATBANK
A Central Government Agency + local organisations	MGOVTLOC
Any organisation meeting a set standard to provide carbon accounts	MANY
Market operation	
Government sets the price of permits on an annual basis	OGOVT
The market determines the price – no limits	OMKT
The market determines the price government sets a price ceiling	OMKTCEIL
Permit Price	
£5, £10, £25, £50, £100, £250, £500 per annual tonne of CO_2	

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1222 **Table 2: CT Attributes and Levels**

Attributes and levels	Code
How tax works	
All carbon consumption is taxed, no hypothecation - revenues go to the general tax budget	RGEN
All carbon consumption is taxed and the revenue is spent on technology to improve energy efficiency	RTECH
All carbon consumption is taxed and the revenue is spent on measures such as more public transport to make it easier for individuals to change their behaviour	RCHANGE
All carbon consumption is taxed and the revenue is used to cut income tax	RINC
All carbon consumption is taxed and all the revenue is used to cut council tax	RCOUNCIL
All carbon consumption is taxed. All adults are given a lump sum £X	RLUMP
All adults are given an exemption from the tax – up to the 4 tonnes CO_2, like an income tax threshold.	RTHRESH
Tax Rate	
£5, £10, £20, £50, £100, £150, £250 per tonne of CO_2	

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1224 **Table 3: Attributes and Levels in each SP Exercise**

	Option 1					Option 2				
	PCT_A					PCT_B				
SP1	Permit Price	Permit Allocation	Permit Life	Transactions	Management of Carbon Accounts	Permit Price	Permit Allocation	Permit Life	Transactions	Management of Carbon Accounts
	£5 £25 £50 £100 £500	AINDCHILD AIND40 AADULT ACONS AEXTNEED	P1	TAUTO	MGOVT MNAT MNATBANK MGOVTLOC MANY	£5 £10 £25 £50 £250	AINDCHILD ACONS AHOUSE AGOVT AFINNEED	P1 P5 P1_50 P1_25	TAUTO TADD	MGOVT
SP2	Permit Price	Permit Allocation	Purchase Limits	Market Operation	Excess Permits	Permit Price	Permit Allocation	Purchase Limits	Market Operation	Excess Permits
	£5 £25 £50 £100 £500	AINDCHILD AIND40 AADULT ACONS AEXTNEED	LNONE	OMKT	ECHOOSE EMKTCHY EPRIV EMKT	£5 £10 £25 £50 £250	AINDCHILD ACONS AHOUSE AGOVT AFINNEED	LNONE L1/4 L1/2 LSAME	OMKT OGOVT OMKTCEIL	ECHOOSE
	PCT					CT				
SP3	Permit Price	Permit Allocation	Permit Life	Scope of the Scheme	Management of Carbon Accounts	Tax Rate	How Tax Works			
	£5 £10 £25 £50 £100 £250 £500	AINDCHILD AIND40 AADULT ACONS	P1 P5 P1_50 P1_25	SALL SHCAR SHCARAIR	MGOVT MNAT MNATBANK MGOVTLOC MANY	£5 £10 £20 £50 £100 £150 £250	RGEN RTECH RCHANGE RINC RCOUNCIL RLUMP RTHRESH			
SP4	Permit Price	Permit Allocation	Purchase Limits	Market Operation	Excess Permits	Tax Rate	How Tax Works			
	£5	AINDCHILD	LNONE	OMKT	ECHOOSE	£5	RGEN			

	£10 £25 £50 £100 £250 £500	AIND40 AADULT ACONS	L1/4 L1/2 LSAME	OGOVT OMKTCEIL	EMKTCHY EPRIV EMKT	£10 £20 £50 £100 £150 £250	RTECH RCHANGE RINC RCOUNCIL RLUMP RTHRESH			

Table 4: Full and Preferred Models

Attribute	Model I	Model II	Attribute	Model I	Model II
Permit Allocation			**Management of Carbon Accounts**		
AINDCHILD	Base	Base	MGOVT	Base	Base
AIND40	-0.033 (0.5)	n.s	MNAT	0.251 (2.4)	0.268 (2.8)
AADULT	-0.165 (2.2)	-0.172 (2.7)	MNATBANK	0.305 (2.4)	0.319 (2.7)
ACONS	-0.064 (1.0)	n.s	MGOVTLOC	-0.119 (0.9)	n.s
AEXTNEED	0.357 (3.3)	0.350 (3.4)	MANY	0.216 (1.7)	0.233 (1.8)
AHOUSE	0.108 (1.0)	n.s	**Market Operation**		
AGOVT	-0.321 (2.8)	-0.289 (2.8)	OMKT	Base	Base
AFINNEED	-0.032 (0.3)	n.s	OGOVT	0.269 (3.4)	0.242 (3.8)
Excess Permits			OMKTCEIL	0.106 (1.2)	n.s
ECHOOSE	Base	Base	**How tax works**		
EMKT	-0.112 (1.7)	-0.145 (2.5)	RCOUNCIL	Base	Base
EPRIV	-0.019 (0.2)	n.s	RINC	-0.177 (1.2)	n.s
EMKTCHY	-0.157 (1.6)	-0.182 (1.9)	RLUMP	-0.116 (0.8)	n.s
Permit Life			RTHRESH	0.429 (2.9)	0.558 (4.9)
P1	Base	Base	RGEN	-0.400 (2.8)	-0.277 (2.6)
P5	0.140 (1.4)	0.165 (1.8)	RTECH	0.0233 (0.2)	n.s
P1_25	-0.019 (0.1)	n.s	RCHANGE	0.335 (2.3)	0.454 (4.2)
P1_50	0.272 (2.6)	0.301 (3.2)	**Permit Price / Tax Rate**		
Purchase Limits			$CostPCT_H$	-0.000196 (5.1)	-0.000204 (5.3)
LNONE	Base	Base	$CostPCT_L$	0000098 (0.9)	n.s
L1/4	0.071 (0.8)	n.s	CostCT	-0.000449 (6.4)	-0.000398 (6.2)
L1/2	0.022 (0.3)	n.s	$CostCT_G$	-0.00124 (1.6)	n.s
LSAME	0.391 (2.5)	0.402 (2.7)	**ASCs**		
Scope of the Scheme			ASC1	-0.624 (7.3)	-0.651 (9.9)
SALL	Base	Base	ASC2	0.324 (4.2)	0.376 (6.4)
SHCAR	0.216 (1.1)	n.s	ASC3	-1.00 (5.8)	-0.962 (8.5)
SHCARAIR	0.095 (0.5)	n.s	ASC4	0.374 (3.3)	0.255 (3.8)
Transactions			ASC5	-0.202 (1.6)	n.s
TAUTO	Base	Base	Adjusted ρ^2	0.034	0.035
TADD	0.026 (0.3)	n.s	Log likelihood	-5808.34	-5817.25

Note: Coefficient estimate with t ratio in parentheses

1230 **Table 5: Forecast Levels of Acceptability**

					CF=CA[8] = 0	CF-CA = 1.6			CF-CA = 3.8			CF-CA = 6		
						Permit Price								
						£25	£100	£250	£25	£100	£250	£25	£100	£250
	Permit Allocation	Permit Life	Scope of the Scheme	Management of Carbon Accounts										
1	AINDCHILD	P1	SALL	MGOVT	0.28	0.27	0.27	0.26	0.27	0.26	0.24	0.27	0.25	0.22
2	AINDCHILD	P1	SALL	MNATBANK	0.34	0.34	0.34	0.33	0.34	0.33	0.30	0.34	0.32	0.28
3	AINDCHILD	P1_50	SALL	MNATBANK	0.41	0.41	0.41	0.40	0.41	0.40	0.37	0.41	0.39	0.34
4	AEXTNEED	P1_50	SALL	MNATBANK	0.50	0.50	0.49	0.48	0.50	0.48	0.45	0.49	0.47	0.43
5	AGOVT	P1	SALL	MGOVT	0.22	0.22	0.22	0.21	0.22	0.21	0.19	0.22	0.20	0.17
	Permit Allocation	Purchase Limits	Market Operation	Excess Permits										
6	AINDCHILD	LNONE	OMKT	ECHOOSE	0.59	0.59	0.59	0.57	0.59	0.57	0.55	0.59	0.56	0.52
7	AINDCHILD	LNONE	OGOVT	ECHOOSE	0.65	0.65	0.64	0.63	0.65	0.63	0.60	0.64	0.62	0.58
8	AINDCHILD	LSAME	OGOVT	ECHOOSE	0.73	0.73	0.73	0.72	0.73	0.72	0.70	0.73	0.71	0.67
9	AEXTNEED	LSAME	OGOVT	ECHOOSE	0.80	0.80	0.79	0.78	0.79	0.78	0.76	0.79	0.78	0.74
10	AINDCHILD	LNONE	OMKT	EMKTCHY	0.55	0.55	0.54	0.53	0.54	0.53	0.50	0.54	0.52	0.47
11	AGOVT	LNONE	OMKT	EMKTCHY	0.48	0.47	0.47	0.46	0.47	0.46	0.43	0.47	0.45	0.40
12	AEXTNEED	LNONE	OMKT	ECHOOSE	0.67	0.67	0.67	0.66	0.67	0.66	0.63	0.67	0.65	0.60
			CF=4			CF= 5.6			CF= 7.8			CF=10		
			Tax Rate											
	How Tax Works		£25	£100	£250	£25	£100	£250	£25	£100	£250	£25	£100	£250
13	RCOUNCIL		0.55	0.52	0.46	0.55	0.51	0.43	0.54	0.49	0.37	0.54	0.46	0.32
14	RTHRESH		0.68	0.66	0.60	0.68	0.64	0.56	0.68	0.62	0.51	0.67	0.60	0.45
15	RCHANGE		0.66	0.63	0.58	0.66	0.62	0.54	0.65	0.60	0.48	0.65	0.58	0.43
16	RGEN		0.48	0.45	0.40	0.48	0.44	0.36	0.48	0.42	0.31	0.47	0.40	0.27

[8] Where CF = Carbon Footprint, CA = Carbon Allowance

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