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COMMONS DEED

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

27

28

29

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

32

33

34 **1. Introduction**

35

36 In the light of compelling evidence of the need to make very deep cuts in
37 greenhouse gas emissions (IPCC, 2007; Stern, 2006), the UK Government
38 has committed to an 80% cut by 2050 relative to 1990 levels (Climate Change
39 Act, 2008). Transport and domestic energy are the only sectors where
40 emissions in 2006 exceeded those of 1990 (DECC/Defra, 2009) and together
41 personal transport and domestic energy account for 42% of UK CO₂
42 emissions (DTI, 2007). This scenario is typical of the challenges facing many
43 developed countries.

44

45 Personal Carbon Trading (PCT) offers a potentially powerful and innovative
46 instrument with which to achieve demanding reductions in carbon emissions
47 and has aroused interest at national government level in the UK (Defra,
48 2008a). PCT is a downstream trading mechanism normally understood to
49 involve an initial allocation of carbon permits to individuals based on carbon
50 reduction targets, with individuals able to buy and sell permits according to
51 their desired carbon consumption and prevailing permit prices. However, the
52 precise structure of a scheme could vary considerably given the potential
53 range of additional design features including management of individual carbon
54 accounts, market operation, regulation, permit allocation, scope of coverage
55 and transaction costs. Policy makers would be interested in which scheme
56 designs have the greatest acceptability amongst the general public.

57

58 PCT's natural downstream comparator policy instrument is the conceptually
59 familiar Carbon Tax (CT) applied to consumer products. In accordance with
60 Weitzman (1974), tradable permits and taxes are theoretically equivalent in
61 terms of both efficiency and effectiveness. It is better to fix the price through a
62 tax where there is uncertainty over the cost function and to fix the quantity
63 through a tradable system when there is uncertainty over the damage function
64 (Montero, 2002; Pizer, 2002). Recent work on trading and tax has looked at
65 political economy aspects and concentrated on welfare effects and political
66 acceptability (e.g. Babiker et al., 2003; Brannlund and Nordstrom, 2004; Crals
67 and Vereeck; 2005, Dinan and Rogers; 2002, Parry and Small, 2005; Pezzey,
68 2003; West and Williams, 2004). The use of collected revenues and the way
69 permits are allocated have been identified as the main determinants of
70 distributional impacts and consequent political acceptability¹.

71

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

77

78 In the context of climate change the damage function is uncertain and
79 potentially steep with high costs of missing abatement targets; price
80 elasticities of demand for both vehicle fuel and domestic energy are low
81 (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)

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

92

93 Individual involvement in environmental policy has been advocated in various
94 recent studies (Ahlheim and Schneider, 2002; Israel, 2007; Malueg and Yates,
95 2006; Rouse, 2008; Shammin and Bullard, 2009). A PCT scheme appears to
96 have the potential to target individually generated carbon emissions by taking
97 into account source heterogeneity and providing visibility to fuel and energy
98 consumption.

99

100 However, whilst theory might provide some insights into the attractiveness of
101 PCT and CT, it is ultimately personal preference that determines their
102 acceptability and the impact of specific scheme features on this acceptability.
103 Some PCT scheme designs might be regarded as fairer (for example, with
104 respect to the way permits are allocated) and allowing more personal choice
105 (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 Batty (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

131 et al., 2009; Owen et al., 2008; Von Knobelsdorff, 2008; Wallace, 2009,
132 YouGov, 2006a and 2006b). Approaches vary from highly qualitative focus
133 groups and in-depth interviews to postal and internet surveys and national
134 polls. Support for PCT lies in the range 25 to 47%². Most of these studies do
135 not use hypothecation or revenue recycling in the CT option nor do they
136 mention the higher costs of PCT. Nevertheless, this level of expressed
137 support for what is after all a very unfamiliar idea provides a promising base
138 from which to explore acceptability. Polling evidence suggests that support
139 for green taxes increases with hypothecation of revenues, especially if
140 directed to tax cuts and environmental or energy expenditures, when support
141 can exceed 70% (BBC, 2007; Green Fiscal Commission, 2007; Ipsos Mori,
142 2006; YouGov, 2006c). However, most work to date on the acceptability of
143 PCT or CT has asked for responses to fixed designs. No studies to date have
144 systematically explored the impact of varying design features on acceptability.

145

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

154

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.

155 **3. Survey design**

156

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

163

164 **3.1 SP Methods**

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

174

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

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

187

188 **3.2 PCT design attributes**

189 Some elements of scheme design were fixed, including the free annual
190 carbon allowance of 4 tonnes of CO₂ per person, similar to the actual average
191 level of 4.25 tonnes (DTI, 2007). All respondents completed the "ACT on CO₂"
192 carbon calculator (Defra, 2007a) to estimate their emissions from domestic
193 energy and transport³. Thus all respondents were aware of their starting point
194 with respect to emissions and hence the impact of the proposed scheme on
195 them personally.

196

197 The attributes and levels selected to compose PCT schemes, with the
198 wording used in the survey, are given in Table 1. Note that in many cases we
199 have no a priori expectations of the relative importance of the different
200 attribute levels due to the novelty of the schemes and since individuals'
201 circumstances vary as will the extent to which individual or social
202 considerations might influence preferences. In determining the levels for
203 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.

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

206

207 **Table 1 about here**

208

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

220

221 Permit allocation to industry through the European Trading System has
222 reflected historic emissions (Ellerman and Buchner, 2007). An allocation
223 based on current consumption (ACONS) was included to establish whether
224 individual preferences recognise the 'rights' of high emitters (Seyfang et al.,
225 2007).

226

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

229 2008), including those with higher energy needs through disability, poor
230 housing or location relative to facilities. The principle of equal per capita
231 allocation has been questioned partly on the grounds of unequal needs
232 (Starkey, 2008). Equity is addressed here through higher allocations
233 (AEXTNEED) or financial support (AFINNEED) to those with greater need and
234 an allocation based on Government assessment of need (AGOVТ). These
235 levels are used to assess whether there is a difference in the acceptability of
236 financial (AFINNEED) and effectively in-kind support (AEXTNEED). The
237 acceptability of AGOVТ may be different for two possible reasons. Firstly,
238 respondents may think that a Government assessment of need would not
239 align with that described under AEXTNEED and AFINNEED and might be
240 politically determined. Secondly, the response may vary simply because of
241 distrust of Government.

242

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

248

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

254

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

259

260 Two levels of permit life of one year (P1) and 5 years (P5) exclude banking.
261 The remaining two levels both have a one year lifetime and one allows up to
262 50% of permits to be banked for 5 years (P1_50) and the other up to 25% to
263 be banked for 10 years (P1_25).

264

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

269

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

273

274 Scope of the Scheme: A scheme could cover all energy consumption in the
275 home and personal transport including travel by car, air, and public transport
276 modes⁴. We might expect some to have a preference for a broader scheme,

⁴ Embodied emissions are not included.

277 as it would offer more options for CO₂ reduction. However, others might prefer
278 modes of transport they use extensively to be omitted.

279

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

283

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

291

292 Management of Carbon Accounts: This attribute was included to explore
293 issues of trust and efficiency (Dresner et al., 2006; Hsu et al., 2008). The
294 levels include two single operator options; a Central Government agency
295 (MGOVT) and a national not for profit operator (MNAT). The remaining levels
296 each offer some choice; a combination of a national not for profit operator and
297 banks (MNATBANK⁵), a Central Government Agency and local organisations
298 (MGOVTLOC), and an open market where any suitable operator may offer
299 carbon accounts (MANY).

300

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

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

309

310 Permit Price: The permit price range encompasses recent prices of CO₂ per
311 tonne (in 2008 prices) of £42.61 from the Stern Review (Stern, 2006), the £26
312 UK Government shadow price (Defra, 2007b), the new mitigation based
313 central non-traded sector value of £50 (DECC, 2009) and £19.90 as the
314 European Trading System trading price (pointcarbon.com, 24th July, 2008).
315 The higher levels cover the expected low price elasticity of demand for fossil
316 fuels, and the Wadud et al. (2008) finding that a \$500 per tonne CO₂ price
317 would only reduce gasoline consumption in the USA by 15%, whilst the lower
318 prices were included to assess whether they were critical to acceptability.

319

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

325

326 **3.3 CT attributes**

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

328

329 **Table 2 about here**

330

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

345

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

349

350 Tax Rate: The tax rates were set between £5 and £250 per tonne of CO₂,
351 largely in line with the PCT permit prices.

352

353 **3.4 Stated Preference exercises**

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

362

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

371

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

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

376

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

380

381 **Table 3 about here**

382

383 **4. Data Collection and Characteristics**

384

385 The survey was implemented in two phases. Firstly, at a Citizens Forum in
386 Cardiff in January 2008 involving 79 respondents recruited locally to be
387 broadly representative of the Energy Saving Trust market segmentations in
388 order to capture a diverse range of lifestyles and opinions (RSA, 2008).
389 Secondly, a survey in the South East of England involving 208 respondents
390 with on-street recruitment where people were asked to participate in a survey
391 about climate change of around 45 minutes duration and offered £10 as an
392 incentive to participate. Interviewers were asked to recruit respondents to
393 achieve a spread of gender, employment type, age group and car ownership.
394 The average carbon footprint was 5.6 tonnes CO₂ split roughly 40% transport
395 and 60% domestic energy use. During the interview, which also covered
396 socio-economic characteristics, attitudes and behaviours, each respondent
397 completed two separate SP exercises, one PCT v PCT and one PCT v CT.

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

400

401 The sample was fairly evenly split 52% male and 47% female (1% missing).
402 There is also a good representation across the age groups of 18 to 29 years
403 (24%), 30 to 44 years (30%), 45 to 60 years (24%) and over 60 (21%), with
404 again 1% missing data. Unfortunately, 22% respondents did not disclose their
405 income group, and therefore in the analysis employment status is a crude
406 proxy for income. The average household size is 2.7 with just over half the
407 respondents living in adult only households. About half the sample live in their
408 own homes with the rest renting or living with their family. More than half the
409 sample were employed full or part time. 32% of respondents are in non-car
410 owning households, somewhat above the national average of 24%
411 (Department for Transport, 2008). This was intentional, as car ownership was
412 the only easily available screening question to yield an indication of carbon
413 footprint and clearly we needed to recruit respondents both below and above
414 our permit threshold.

415

416 **5. Analysis**

417

418 **5.1 Model structure**

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

422 Thus option 1 is chosen if:

423

424
$$U_{i1} > U_{in} \quad \text{for all } n, n \neq 1 \quad (1)$$

425

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

431

432
$$U_{i1} = V_{i1} + \varepsilon_{i1} \quad (2)$$

433

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

437

438
$$V_{i1} = \sum_{k=1}^K \alpha_k X_{ki1} \quad (3)$$

439

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

445

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

451

$$452 \quad P_{i1} = \Pr[(V_{i1} + \varepsilon_{i1}) > (V_{in} + \varepsilon_{in})] \text{ for all } n, n \neq 1 \quad (4)$$

453

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

459

$$460 \quad P_{i1} = \frac{e^{V_{i1}}}{\sum_{j=1}^n e^{V_{ij}}} \quad (5)$$

461

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

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

474

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

481

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

487

488 A better approach is to pool the data across the SP variants and the two
489 response scales. However, such an approach needs to recognise that the
490 separate data sets will have different amounts of random error, due to
491 different degrees of attribute familiarity and difficulty and different response
492 scales and choice context. Given that the coefficients of logit models are
493 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

568 Whilst there is no support for financial assistance for those in greater need
569 (AFINNEED), there is a preference for support through allocating extra
570 permits (AEXTNEED). This may be because it is in-kind support targeted at a
571 recognised consumption need. Qualitative research on PCT also found
572 support for extra help for vulnerable groups (Bird et al., 2009; Owen et al.,
573 2008) and research on greenhouse gas reduction policies identified support
574 for discounts to low income households (Dietz and Atkinson, 2009).

575

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

583

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

589

590 Permit Life: The opportunity to be able to bank 25% for up to 10 years
591 (P1_25) was not deemed attractive relative to the base of a one year permit
592 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.

618

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

624

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

628

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

636

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

643

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

654

655 There is, however, a strong preference for an exemption from the tax up to the
656 4 tonnes threshold (RTHRESH). This is preferred to RLUMP even though the
657 latter would give a greater benefit to low carbon users and the two schemes
658 would be the same for high carbon users. It may be that exemption
659 thresholds are a familiar concept and perceived to be efficient due to their
660 ease of application, whereas some might not believe that the government
661 would make lump sum payments. Using the carbon tax revenues to make it
662 easier to change behaviour and reduce consumption of carbon (RCHANGE)
663 was also strongly favoured over their use for financial compensation.
664 Interestingly, Dresner et al. (2006) and IPSOS MORI (2006) found stronger
665 support for taxation of energy and aviation respectively where revenues were
666 recycled into environmental expenditures rather than tax cuts.

667

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 coefficient⁶.

699

700 Alternative Specific Constants (ASCs): Such constants discern the net effect
701 on utility of unobserved variables, such as, say, basic attitudes toward PCT⁷
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.

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

719

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

724

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

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

741

742 **5.3 Model Application**

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

747

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

751

$$752 \quad P_1 = \frac{1}{1 + e^{V_2 - V_1}} \quad (6)$$

753

754

755 The probability that the scenario is acceptable (P_1) is a function of the
756 difference in the utility of option 1 and option 2. The utility of option 2 (V_2), as
757 we have stated, is set to zero. The utility of option 1 (V_1) represents a
758 particular set of attributes that compose a scenario along with the weights
759 estimated for the relevant attributes and reported in Table 4. Taking the fourth
760 scenario in Table 5, where the PCT scenario specifies allocation as
761 AEXTNEED, the life of the permits as P1_50, scope as SALL, and the
762 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

$$766 \quad V_1 = -0.962 + 0.350 AEXTNEED + 0.301 P1_50 + 0.0 SALL \\ 767 \quad + 0.319 MNATBANK - 0.000204 (CF - CA) CostPCT_H = -0.025$$

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

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

789

790 **Table 5 about here**

791

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

805

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

811

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

818

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

823

824 We can consider the potential additional set up and operational costs of a
825 PCT over and above those of CT utilising the recent analysis by Lockwood
826 (2009) who estimates an annual additional cost per person of approximately
827 £50 based on defra central estimates and his own central estimate of £28. If
828 we assume a tax of £50 for the CT based on the new cost of carbon (DECC,
829 2009) and a price per tonne of £78 to £100 for the PCT and compare
830 acceptability, for the “best” designs and average carbon consumption, we find
831 that the CT achieves 67% acceptance and the PCT 79% acceptance. This
832 suggests that set up costs may not be a deal breaker for PCT. However, if
833 these costs were outlined to respondents as set up and running costs we
834 must recognise the possibility that the results could have been different.

835

836 **6. Conclusions**

837

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

842

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

850

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

857

858 A key result is that a PCT or CT can be politically acceptable. This is not as
859 implausible as it first seems. Firstly, previous studies, admittedly with fixed
860 designs, do evidence reasonable degrees of acceptability. Secondly, there are
861 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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1197 **APPENDIX A Description of the two schemes as they appeared to**
1198 **respondents**
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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 CO₂.

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

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1202 **APPENDIX B Example Choice Cards from the two stated preference**
 1203 **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 |

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| | | | | |
|---|---|---|---|---|
| <i>I would prefer</i> | | Option 1 <input type="checkbox"/> | Option 2 <input type="checkbox"/> | |
| <i>I find option 1</i> | | | | |
| Highly acceptable <input type="checkbox"/> | Moderately acceptable <input type="checkbox"/> | Neither acceptable nor unacceptable <input type="checkbox"/> | Moderately unacceptable <input type="checkbox"/> | Highly unacceptable <input type="checkbox"/> |
| <i>I find option 2</i> | | | | |
| Highly acceptable <input type="checkbox"/> | Moderately acceptable <input type="checkbox"/> | Neither acceptable nor unacceptable <input type="checkbox"/> | Moderately unacceptable <input type="checkbox"/> | Highly unacceptable <input type="checkbox"/> |

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| Choice Card 2 | | | | | |
|---|---|---|--|---|--------------------------------------|
| ATTRIBUTE PCT | Option 1 | | Option 2 | | ATTRIBUTE TAX |
| <i>Allocation of permits</i> | 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 | | <i>How the tax works</i> |
| <i>Permit sale / purchase</i> | £250 per tonne of CO ₂ | | £10 per tonne of CO ₂ | | <i>Cost per tonne CO₂</i> |
| <i>An independent regulator oversees management of carbon accounts provided by:</i> | a central government agency | | | | |
| <i>Lifetime of permits</i> | permits expire after one year but 50% may be banked for up to 5 years | | | | |
| <i>Scope of the scheme</i> | emissions from the home and all transport use: private car, public transport and air travel | | | | |
| <i>I would prefer</i> | Option 1 <input type="checkbox"/> | | Option 2 <input type="checkbox"/> | | |
| <i>I find Option 1</i> | | | | | |
| Highly acceptable <input type="checkbox"/> | Moderately acceptable <input type="checkbox"/> | Neither acceptable nor unacceptable <input type="checkbox"/> | Moderately unacceptable <input type="checkbox"/> | Highly unacceptable <input type="checkbox"/> | |
| <i>I find Option 2</i> | | | | | |
| Highly acceptable <input type="checkbox"/> | Moderately acceptable <input type="checkbox"/> | Neither acceptable nor unacceptable <input type="checkbox"/> | Moderately unacceptable <input type="checkbox"/> | Highly unacceptable <input type="checkbox"/> | |

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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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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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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 | | | |
|--|---|---------------------------|-----------------------|-------------------|--------------------------|---|--|--|--|--|

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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 |

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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 | | | |
| 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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