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Survey

Personal carbon trading: A critical survey Part 1: Equity

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ABSTRACT

In recent years, there has been considerable discussion within UK climate policy circles regarding the appropriateness of *personal carbon trading* as an instrument for greenhouse gas emission reduction. This paper is the first in a two-part survey of personal carbon trading (PCT), the term used here to describe proposed (sub-)national greenhouse gas emission trading schemes under which at least some emissions rights are allocated to and surrendered by individuals. After introducing the various proposed PCT schemes, the paper compares, in terms of equity, the two most-discussed PCT schemes with two alternative emission trading schemes and a carbon tax. The papers' two key findings are as follows. First, there are strong arguments that the equal per capita allocation proposed under some instruments is not completely fair. Second, the five instruments compared can be equivalent in terms of their equity. Along with equity, efficiency and effectiveness make up three key criteria for comparing environmental policy instruments. As PCT has no advantage in terms of equity, the paper concludes that any case for PCT will depend on it having advantages in terms of efficiency and/or effectiveness. Whether PCT has such advantages is explored in Part 2.

1. Introduction

In recent years, there has been considerable discussion within UK climate policy circles regarding the appropriateness of *personal carbon trading* as an instrument for greenhouse gas emission reduction. This paper is the first in a two-part survey of personal carbon trading (PCT), the term used here to denote (sub-)national emission trading schemes for reducing emissions from fuel combustion, under which at least some emissions rights are allocated to and surrendered by eligible individuals. Eligible individuals, henceforth simply "individuals", are, roughly speaking, adults. The term is fully specified in Section 7.

The paper compares the two most widely discussed PCT schemes

- Tradable Energy Quotas (TEQs)
- Personal Carbon Allowances (PCAs)

with two proposed alternative trading schemes

- Cap and Dividend (C&D)
- Cap and Share (C&S)

and the carbon tax

- Tax and Dividend

Emission trading schemes are traditionally classified as *upstream* or *downstream*. Under upstream schemes, emission rights are surrendered by fossil fuel suppliers and, under downstream schemes, by energy users. Under this classification, TEQs and PCAs are types of downstream scheme, whilst C&D and C&S are types of upstream scheme. What then is the rationale for comparing upstream schemes with downstream schemes and a carbon tax? In a word, *equity*, as all five schemes take what might be termed a "(roughly) equal" approach to emission reduction.

Along with equity, efficiency and effectiveness make up three key criteria for comparing environmental policy instruments (Gunningham and Grabosky, 1998; Stern, 2008). Efficiency and effectiveness are the focus of Part 2 of this survey following the focus on equity in Part 1, which proceeds as follows. Section 2 sets out the scope of the schemes discussed in this survey along with the emissions typology used. Section 3 then describes the range of proposed PCT schemes whilst the three alternatives to PCT are described in Section 4. This is followed by an extended analysis in Sections 5 and 6 of the approaches to equity of TEQs, PCAs and the three alternatives. Section 7 discusses the issue of who should be an eligible individual and Section 8 briefly concludes.

When comparing PCT with alternatives, the devil is very much in the detail and a two-part survey provides the opportunity to explore in detail various aspects of equity, efficiency and effectiveness. Thus, this survey complements the recent single-paper survey by Fawcett (2010).

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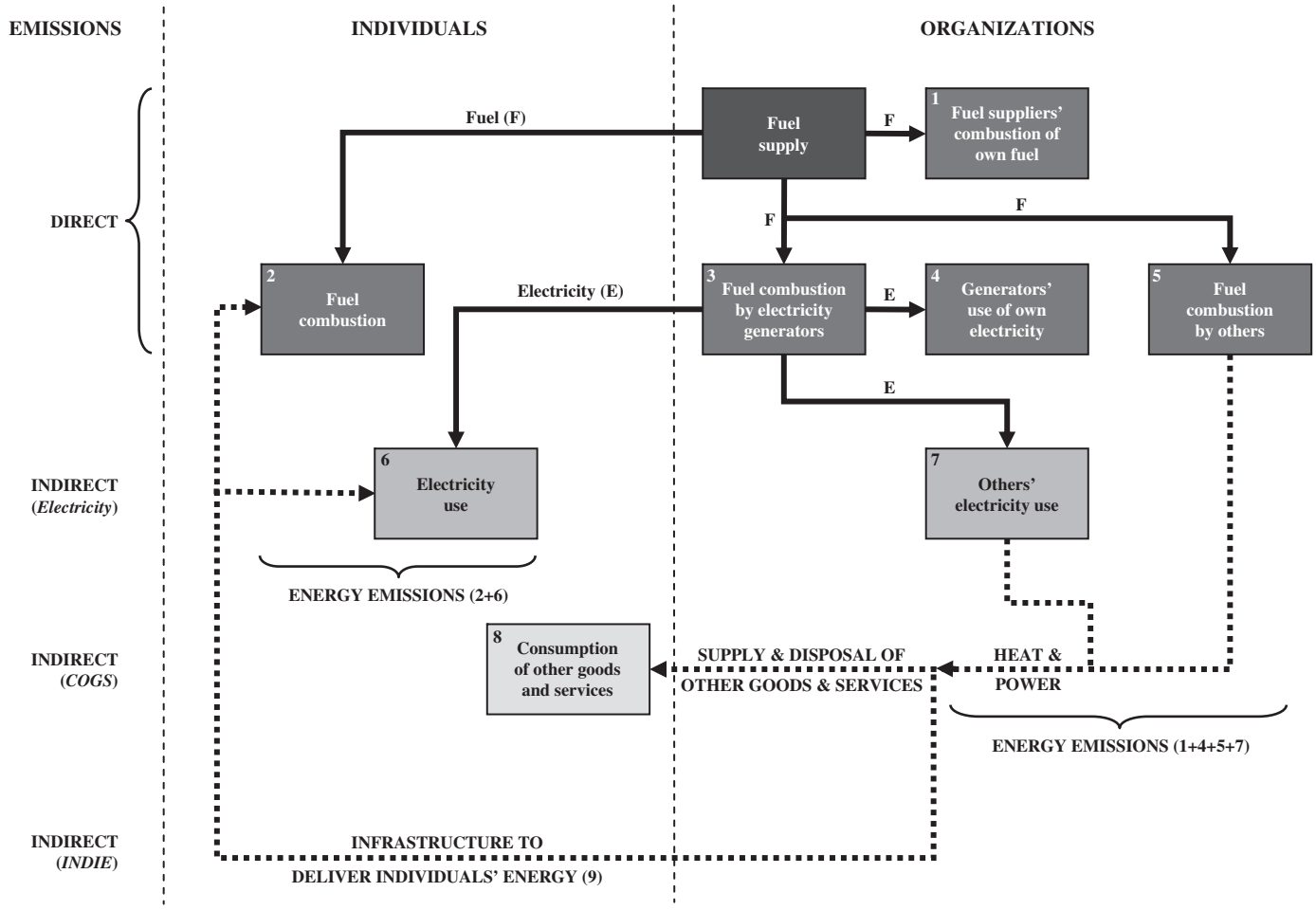

Fig. 1. Emissions from fuel combustion: a typology.

2. Preliminaries

2.1. Scope

The schemes discussed are all schemes for reducing emissions from *fuel combustion*. Of the greenhouse gases regulated by the Kyoto Protocol, fuel combustion releases carbon dioxide, methane and nitrous oxide. In, for example, the UK, emissions from fuel combustion constitute by far the largest component of total emissions. Carbon dioxide emissions from fuel combustion account for over 95% of total carbon dioxide emissions in the 2008 inventory and emissions from fuel combustion of all three gases account for 85% of total inventory emissions (MacCarthy et al., 2010).

2.2. Emissions Typology

Fig. 1 shows a nation's emissions from fuel combustion. These can be classified as *direct* and *indirect*. Individuals or organizations emit directly when they themselves combust fuel, and, in Fig. 1, organization's direct emissions are divided into those from the generation of electricity and from other combustion activities. Individuals or organizations emit indirectly when they consume goods or services, the provision of which involved direct emissions by one or more (other) organizations. Thus, after accounting for transmission and distribution losses, an electricity generator's direct emissions are equal to the indirect emissions from the electricity use of the individuals and organizations that constitute its customers plus the direct emissions from the small proportion of its generated electricity it uses for operational purposes.

Individuals customarily refer to their use of fuel and electricity as their *energy use*. Thus, their (direct) emissions from fuel combustion (Box 2) and (indirect) emissions from electricity use are here referred to as their *energy emissions*. Similarly, organizations' energy emissions consist of emissions from *all organizations*' electricity use (4 + 7) and *non-generators*' fuel combustion (1 + 5).[1]

Organizations' energy emissions are ultimately embodied in the energy, other goods and services consumed by individuals. Organizations' energy emissions embodied in the energy individuals consume are those resulting from the provision of the infrastructure need to deliver individuals' energy, and are referred to as individuals' INDIE emissions (9). Organizations' remaining energy emissions are embodied in the other goods and services individuals consume, and are referred to as individuals' COGS emissions (8).[2] Thus

Total emissions from fuel combustion

= individual energy (2 + 6) + organizational energy (1 + 4 + 5 + 7) emissions

= total energy emissions(1 + 2 + 4 + 5 + 6 + 7)

= individual energy (2 + 6) + COGS (8) + INDIE (9) emissions

[1] Emissions from *generators'* fuel combustion (3) are equivalent to those from all organizations' electricity use (4 + 7).

[2] These include emissions embodied in their consumption of government services.

3. Personal Carbon Trading Schemes

Using this typology, Section 3 describes the various proposed PCT schemes, beginning with the two most widely discussed: TEQs and PCAs.

3.1. Tradable Energy Quotas (TEQs)[3]

Originally known as *Domestic Tradable Quotas*, TEQs were formulated by Fleming in the mid-1990s (Fleming, 1996, 1997, 2007; Fleming and Chamberlin, 2011). The scheme consists of three elements: setting the carbon budget, surrendering emissions rights and allocating emissions rights. Of course, rights must be allocated before being surrendered but, for ease of exposition, the elements are described in this order.

3.1.1. Scheme Description

The carbon budget is the maximum quantity of Kyoto gases from fuel combustion that a nation may emit annually and is reduced each year in line with national emission reduction targets. The budget is set 20 years ahead to give society a long-term signal regarding emission reduction.

Emissions rights are known as *carbon units*, with a unit defined as the right to emit 1 kg of carbon dioxide equivalent. Whenever (1) individuals and organizations other than electricity generators purchase fuel or electricity and (2) fuel suppliers and electricity generators use their own fuel or electricity for operational purposes, they must surrender carbon units to cover the emissions (that will be) released by the combustion of the fuel or the generation of the electricity purchased or used. That is, individuals and organizations must surrender units to cover their *energy emissions*.

Each year, a quantity of carbon units equal to the carbon budget is allocated by government to individuals and organizations. The proportion allocated to individuals is equal to the proportion of total energy emissions represented by individual energy emissions in the period prior to TEQs' implementation. (In the UK, the current proportion is around 40%.[4]) Carbon units are allocated to individuals *free* and on an *equal per capita* basis. In addition, child benefit would be increased to reflect the additional energy used and, thus, the additional carbon units required in households with children.

Organizations must purchase units on a national carbon market. Units enter onto the market from two sources. First, the government auctions those units not allocated to individuals, and Fleming proposes that the auction revenue is hypothecated to assist individuals and organizations reduce emissions. Second, those individuals whose energy emissions are below the level permitted by their allocation ("below-allocation individuals") can sell their un-surrendered, surplus units onto the market.[5] Those individuals wishing to emit at a level above that permitted by their initial allocation ("above-allocation individuals") must purchase additional units on the market. Visitors to a nation operating a TEQs scheme are not allocated units and must also purchase units on the market.

3.1.2. Further Details

Each individual's carbon units are deposited in an electronic *carbon account* at regular intervals (perhaps monthly). From here, individuals can surrender units to gas and electricity utilities by direct debit, and to motor fuel retailers by means of a stand-alone *carbon card*.[6] Surrender from a carbon account is here referred to as Type 1 Surrender (S1), see Fig. 2, Box 1.

Under TEQs, high street banks and the post office would act as market makers, buying carbon units at auction and from individuals wishing to sell, and selling units to organizations and individuals wishing to buy.[7] Units would be traded using familiar trading channels: telephone, internet and over the counter. Individuals would periodically receive a *carbon statement* recording the units surrendered from their account and those purchased from and sold to market makers.

Carbon units can also be purchased at the point of sale for immediate surrender. Those using this facility would include (1) individuals (visitors from abroad) without carbon accounts (2) individuals with carbon accounts who have surrendered all their units and (3) individuals at petrol stations with units in their account but without their carbon card. Such a facility would be made possible by energy retailers purchasing units on the carbon market and selling them on to customers. When a retailer purchases units, they pass from the market maker's account to the retailer's. But when a customer purchases units from a retailer, they do not pass to their account from the retailer's. Nevertheless, the customer can still be said to surrender them back to the retailer in that, having acquired ownership of the units through purchase, they immediately relinquish (i.e. surrender) that ownership. Such surrender is here referred to as Type 2 Surrender (S2), see Fig. 2, Box 2. Under TEQs, an individual can engage solely in S2 by arranging for a market maker (e.g. her bank) to purchase her carbon units immediately they are deposited in her carbon account, and then purchasing all units for surrender at the point of sale.[8]

Under TEQs, it is likely that some individuals will wish to know whether their energy emissions are above or below allocation (i.e. above or below the national average). However, as S2 does not involve the flow of units from the individual's carbon account to the retailer's, the surrendered units do not appear in her carbon statement. Thus, she cannot tell from her statement whether she is above or below allocation. The units purchased from utilities and motor fuel retailers would appear, respectively, on utility bills and fuel receipts and thus, in theory, the individual could ascertain her energy emissions through totalling the quantities on her bills and receipts.[9] However this would likely prove too laborious for most.

By engaging solely in S1, an individual ensures that *all* carbon units surrendered are recorded in his carbon statement and, thus, can know from his statement whether and by how much he is above or below allocation. Note that engaging solely in S1 requires above-allocation individuals to purchase additional carbon units from market makers rather than at the point of sale.

Of course, individuals can engage in a mixture of S1 and S2. For example, an above-allocation individual might engage in S1 until their carbon account is empty and then engage in S2 to cover their above-allocation emissions. Note that organizations are also able to engage in S1 and/or S2. The extent to which individuals and organizations engage in S1 and/or S2 is crucial to assessing the efficiency of TEQs and is discussed in Part 2.

3.2. Personal Carbon Allowances (PCAs)

Under TEQs, individuals are allocated emissions rights to cover their energy emissions. However, under PCAs, formulated by Hillman, they would ideally be allocated rights that, in addition, cover the COGS emissions arising from their use of public transport (Hillman and Fawcett,

[3] Fleming uses "Energy" rather than "Emissions" as he regards TEQs as suitable for allocating not only emissions rights but also oil rights in response to "peak oil" (Fleming and Chamberlin, 2011). See Part 2.

[4] Based on the UK's 2008 emissions inventory.

[5] Alternatively, they can save them for future years or gift them to e.g. friends or relatives. It would be possible to include an option to retire units.

[6] Alternatively, a surrender facility could be built into credit/debit cards.

[7] Organizations with the highest energy emissions could instead purchase units directly at auction.

[8] After units are surrendered (by S1 or S2) to energy retailers, for accounting purposes, they are then surrendered up the energy supply chain and back to government.

[9] Presumably, unit surrendered would be converted into emissions, a straightforward conversion as X carbon units surrendered = X kg of emissions.

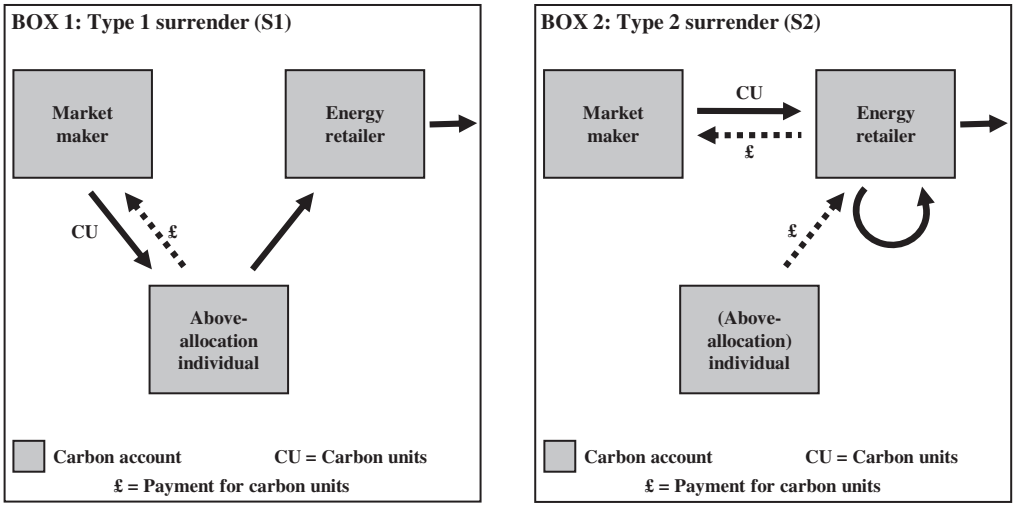

Fig. 2. Type 1 and Type 2 surrender.

2004). Thus, if PCAs were today implemented in the UK, individuals would be allocated 42% of rights as opposed to 40% under TEQs.[10] However, Hillman concedes that the complexity of calculating emissions associated with individuals' public transport journeys is such that it should not be attempted during the initial implementation of PCAs.[11] Thus, during its initial implementation, PCAs would be similar to TEQs in that individuals would be allocated emissions rights covering only their energy emissions, the remaining rights would be auctioned and organizations would purchase rights on the carbon market.[12] The only difference would be in their treatment of parents: under TEQs, parents receive increased child benefit whilst, under PCAs, they instead receive additional emissions rights (Section 6).

Whilst TEQs and PCAs are the most widely discussed PCT schemes, others that have been discussed are described subsequently.

3.3. Ayres Scheme

Under TEQs and the scheme proposed by Ayres (1997a, b), individuals and organizations surrender rights to cover their energy emissions. However, the Ayres scheme differs from TEQs in that individuals are allocated 100% of rights on an equal per capita basis. As under TEQs, organizations purchase rights from market makers but, whereas under TEQs, market makers purchase the majority of rights at auction, under the Ayres scheme they must purchase all of them from the millions of individuals to whom they are allocated. There has been no subsequent research into the Ayres scheme, perhaps because the transaction costs of market makers having to acquire rights from millions of individuals are regarded as too high to make it viable.

3.4. Sectoral Schemes

Whilst the PCT schemes discussed thus far cover an entire economy's energy emissions, others cover only those of a particular sector.

3.4.1. Transport Sector Only

Harwatt (2008), Raux (2010) and Wadud (2011) explore schemes covering emissions from private motoring that utilize the systems and technologies of TEQs (e.g. carbon accounts, carbon cards). Additionally, Raux explores a scheme covering emissions from freight transport. Harwatt's scheme allocates rights to adults on an equal per capita basis whilst Raux discusses two allocations: an equal allocation to (1) adults and children and (2) all car owners. Wadud discusses three allocations: an equal allocation to (1) adults and children (2) adults only and (3) vehicles.

3.4.2. Residential Sector Only

Niemeier et al. (2008) propose a household greenhouse gas cap and trade (HHCT) scheme for the state of California covering residential emissions only, again based around the sorts of systems proposed by Fleming.[13] Two possible allocations are compared: an equal household allocation and an equal per capita allocation.[14]

4. Alternatives to Personal Carbon Trading

Three alternatives to PCT are briefly described subsequently.

4.1. Cap and Dividend (C&D)

Formulated by Barnes (2001, 2008), C&D (formerly *Sky Trust*) is an upstream trading scheme under which all emissions rights are auctioned by government to fuel suppliers. These suppliers purchase rights to cover the carbon content of their fuel, which they surrender back to government when they sell their fuel or use it for operational purposes. Barnes proposes that the auction revenue is allocated to individuals either on an equal per capita basis or with parents receiving an additional share for each child.[15] Thus, whilst, under PCT, individuals are allocated *emissions rights*, under C&D they are allocated *revenue* from the sale of emissions rights.

In December 2009, US senators, Maria Cantwell and Susan Collins introduced into the Senate the *Carbon Limits and Energy for America's Renewal (CLEAR) Act* which proposes a C&D scheme for the US (Cantwell and Collins, 2009). However, as of early 2011, the bill had yet to gain momentum in Congress (Connolly, 2011).[16]

[10] Based on the UK's 2008 emissions inventory. This figure is rather smaller than the 50% quoted by Hillman and Fawcett (2004, p. 126)

[11] For example, the emissions attributable to a bus passenger's journey depend upon factors including the type of bus fuel used, the length of their journey, the (changing) number of passengers on board during their journey and the terrain covered during their journey.

[12] Hillman's mention of an auction (Hillman and Fawcett, 2004, p. 141) suggests he regards PCAs as covering *total* energy emissions. However, due to his focus on how PCAs might affect individuals, the scheme is often characterized as covering *individual* energy emissions only. Unlike Fleming, Hillman makes no mention of what is done with the auction revenue.

[13] Section 1's definition of PCT is formulated to include this proposal for a sub-national scheme.

[14] It is unclear whether those who receive equal shares are adults or all individuals.

[15] Peter Barnes, personal communication, 23 May 2008.

[16] For research papers and other background documents, see Cantwell (2009).

4.2. Cap and Share (C&S)

C&S was formulated by the Irish NGO, Feasta. Rather than being auctioned to fuel suppliers as under C&D, emissions rights under C&S are allocated on an equal per capita basis to individuals, who then sell them on to fuel suppliers via market makers (banks and post offices). Then, as under C&D, the suppliers surrender these rights to government when they sell fuel or use it for operational purposes (Feasta, 2008). Under the original formulation of C&S, rights are posted out to individuals as a single certificate representing their annual allocation. Alternatively it has been suggested that individuals could be posted a booklet containing monthly or quarterly certificates (Cap and Share, 2011b).

C&D is clearly not a PCT scheme as individuals are not allocated rights. By contrast, under C&S, individuals are allocated and trade rights. However, as under C&S's original formulation, the trading element is minimal (certificate sold once a year), proponents chose not to classify it as a PCT scheme.[17] Section 1's definition of PCT is, thus, formulated to exclude C&S.

4.3. Tax and Dividend

Under one variant of C&D, auction revenue is allocated to individuals on an equal per capita basis. From the perspective of equity, the same result is achieved by levying a tax on carbon and allocating the tax revenue on an equal per capita basis (Section 5.2). However, there has been little research into or political activity around such a "Tax and Dividend" scheme.

Proponents of the trading schemes discussed here reject taxation for two main reasons. First, on occasion, they fail to recognize that taxation and trading can deliver similarly equitable outcomes, arguing instead that taxation will uniquely disadvantage low-income groups. Second, they hold that it is important to guarantee meeting carbon budgets and point out that, unlike trading, taxation cannot offer such a guarantee. See, for example, Barnes (2001, p. 42–43), Fleming and Chamberlin (2011, p. 17) and Hillman and Fawcett (2004, p. 133–134).[18]

Of the instruments discussed here, TEQs, PCAs, C&D and C&S are the four that have been the focus of most research and political activity and, for this reason, are those mainly discussed in Sections 5 and 6 which focus on equity. The equal per capita allocation under C&S and one of the C&D variants along with the differential treatment of parents under TEQs, PCAs and the other C&D variant explains the characterization of their approach to equity in Section 1 as "(roughly) equal".

5. TEQs and Auction Revenue

This section introduces a version of TEQs under which the auction revenue is allocated to individuals on an equal per capita basis: henceforth TEQs–EAR (equal auction revenue). TEQs–EAR is contrasted with Fleming's version of TEQs, under which auction revenue is hypothecated, to highlight their potentially different consequences for those on low income.[19]

5.1. TEQs–EAR: The Proportional Scenario

The comparison begins by considering TEQs–EAR under the "proportional scenario", a simplistic scenario under which individuals' emissions are proportional to their income. The more complex real world is discussed in Section 5.4.

In Fig. 3, AB represents the population ordered by emissions and, thus, income. CDBA represents individual energy emissions in Year 1, the year prior to the introduction of TEQs–EAR, with the lowest-emitting individual emitting AC, and the highest, BD. Individual energy emissions make up 40% of total energy emissions (the current UK figure). With the introduction of TEQs–EAR in Year 2, 40% of carbon units are allocated to individuals on an equal per capita basis (EFBA), units that permit a quantity of energy emissions a few percent less than those in Year 1. The emission reduction is CDBA–EFBA or GDF–EGC.

In Fig. 4, IJBA represents the population's COGS + INDIE emissions in Year 1, these "other emissions" making up 60% of total energy emissions. In Year 2, KLBA, the remaining 60% of carbon units, are auctioned by government and permit a quantity of other emissions the same few percent less than those in Year 1. The emission reduction is IJBA–KLBA or MJL–KMI.

Implementation of TEQs–EAR is assumed to result in

1. a reduced emissions factor for electricity
2. increased energy efficiency in new equipment
3. the discovery of abatement opportunities that were cost-effective in Year 1 but undiscovered[20]

If, under these assumptions, AH consume the same level of energy services in Year 2 as in Year 1, then they will become below-allocation individuals with C*G*HA energy emissions and a surplus of EG*C* carbon units (Fig. 3). Under these assumptions, INDIE emissions also fall in Year 2 and, if below-allocation individuals purchase the same basket of other goods and services as in Year 1, so too will their COGS emissions. Thus, in Year 2, below-allocation individuals' other emissions are I*M*HA. Organizations are assumed to pass on the full cost of units and so I*M*HA also represents the cost passed on to below-allocation individuals. However, although they face this additional cost, they also receive KM*HA in auction revenue, giving them additional income of KM*I. Thus, in total, they are better off in Year 2 by EG*C* units + KM*I money (Fig. 4).

If below-allocation individuals save their surplus units for future use then, compared to Year 1, above-allocation individuals and organizations must collectively reduce their energy emissions by GDF + (MJL − KM*I*).[21] Conversely, if below-allocation individuals sell all their surplus units, then above-allocation individuals and organizations must collectively reduce their energy emissions by the smaller quantity (GDF − EG*C*) + (MJL − KM*I*).[22]

However, it is plausible to suppose that, rather than consuming at Year 1 levels and saving KM*I (money) and EG*C* (units or the money from their sale), below-allocation individuals will wish to use KM*I* plus money from the sale of (some of) EG*C* to increase their consumption of energy and/or other goods and services.[23]

5.2. Equity Equivalence of Instruments

Fig. 4 can be used to illustrate how, in terms of equity, TEQs–EAR is equivalent to C&S, Tax and Dividend and the equal per capita version of C&D. That is, if, for simplicity, it is assumed that these instruments

[17] Richard Douthwaite, personal communication, 17 May 2008.

[18] The question of when it is preferable to use a tax or trading has long been discussed (Weitzman, 1974). For a useful, non-mathematical review, see Hepburn (2006).

[19] For simplicity, the increase in child benefit alongside TEQs (Section 3.1) is not considered here.

[20] One referee suggested these assumptions might not hold in the scheme's first year. However, under a regime of (very) rapid emissions reduction they might. And in any case, they are illustrative of what will happen across the lifetime of the scheme.

[21] The share of reductions made by below-allocation individuals and organizations will depend upon the shape of their respective marginal abatement cost curves.

[22] This quantity equals [(GDF − EGC) − CGG*C*] + [(MJL − KMI) − IMM*I*]. (GDF − EGC) + (MJL − KMI) is the reduction in total emissions in Year 2. Above-allocation individuals and organizations must collectively reduce their emissions if, as assumed here, this reduction is greater than CGG*C* + IMM*I*.

[23] If below-allocation individuals wish to purchase more energy *and* engage in S1, they will need to retain some of their EG*C* units. Alternatively, they can sell them all and engage in S2 (Section 3.1.2).

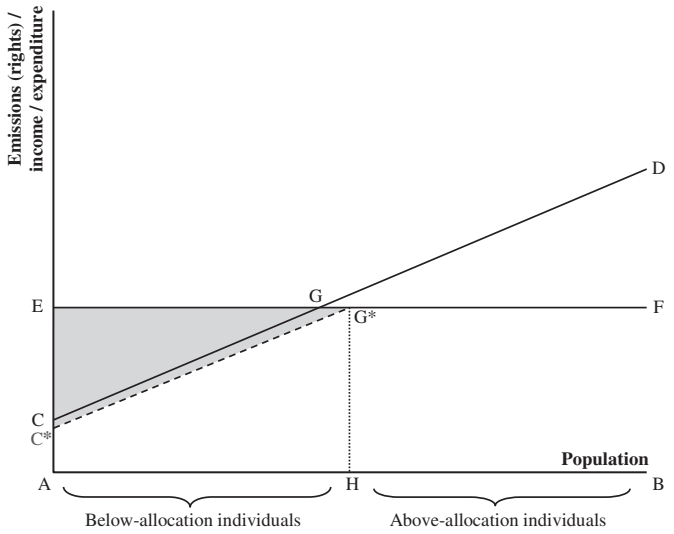

Fig. 3. Below-allocation individuals and energy emissions under TEQs–EAR and the proportional scenario.

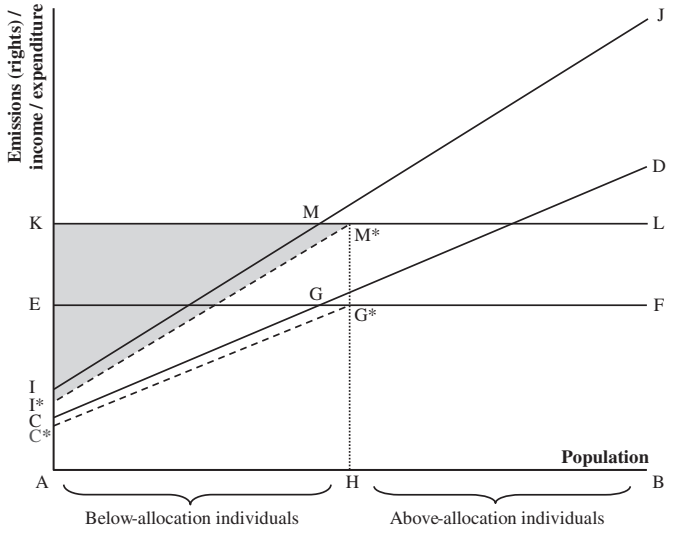

Fig. 4. Below-allocation individuals and other emissions under TEQs–EAR and the proportional scenario.

(1) have equal implementation and participation costs and (2) generate the same level of awareness of abatement opportunities, then below-allocation individuals will be better off to the same degree under each.

Under the equal per capita version of C&D (or under Tax and Dividend), EFBA + KLBA represents the amount raised at auction (or through taxation) and EG*HA + KM*HA the revenue received by below-allocation individuals. Assuming that organizations pass on the full cost of rights (or the tax) and below-allocation individuals consume at the same level in Year 2 as in Year 1, the additional amount they spend on energy and on other goods and services in Year 2 is C*G*HA and I*M*HA. Thus, as under TEQs–EAR, they are better off by EG*C* + KM*I*.

Under C&S, EFBA + KLBA represents both the allocation of rights to individuals and the income they gain from selling those rights to fossil fuel suppliers. Assuming the full cost of rights is passed on down the supply chain, C*G*HA + I*M*HA represents the additional amount spent on energy, other goods and services by below-allocation individuals in Year 2. Thus, again, EG*C* + KM*I* represents the amount by which they are better off.

This discussion illustrates the important point that a variety of instruments can deliver a particular conception of equity, in this case equity as equal shares. However, as the first of the two simplifying assumptions does not hold and the second may not, they may not be able to deliver it with equal efficiency, an issue addressed in Part 2 of this survey.

5.3. TEQs (Fleming): The Proportional Scenario

Under TEQs, auction revenue is hypothecated rather than allocated on an equal per capita basis as under TEQs–EAR. Under the proportional scenario and *before* hypothecation, Individual N in Fig. 5 is financially no better or worse off under TEQs than prior to its implementation as their surplus emissions rights (OP) are equal in value to the additional cost of other goods and services purchased (NQ). Thus, before hypothecation, a small minority of below-allocation individuals (AN) are better off as their surplus emissions (>OP) are worth more than the additional cost of other goods and services (<NQ). However, the majority are worse off. Under TEQs–EAR *all* below-allocation emission are better off (by EG*C* + KM*I). Whether, *after* hypothecation, all below-allocation individuals under TEQs are also better off (to the same degree as under TEQs–EAR) depends on who benefits from the hypothecation and by how much. However, this issue is not one that Fleming addresses.

5.4. TEQs–EAR: The Real World

In the real world, energy emissions are not exactly proportional to income. Whilst, on average, household energy emissions in the UK do rise through the income deciles, they nevertheless vary widely within deciles (Dresner and Ekins, 2004). For example, in the lowest two income deciles, around 70% of households have energy emissions below the national average whilst 30% or so have above-average emissions. In the majority of instances, these above-average energy emissions are due to high residential emissions resulting from occupation of a dwelling with significant heat loss and/or an electric heating system.[24] However, whilst Dresner and Ekins' research has established that a significant minority of low-income households have above-average *energy* emissions,[25] what determines whether a household is better or worse off after the implementation of TEQs–EAR is whether their *total* (i.e. energy + other) emissions are above or below average.

There is currently no detailed data on the relationship between UK households' income and COGS emissions. However, in general, low-income households spend less on other goods and services and will likely have below-average COGS emissions. And if a low-income household has above-average energy emissions, it will be spending a larger proportion of its income on energy and will, thus, have a smaller proportion to spend on other goods and services. Hence, its COGS emissions may be sufficiently below average that, when added to its above-average energy emissions, the result is below-average total emissions.[26] This is illustrated in Fig. 6. Here household R has above-average energy emissions, RS but, when combined with its below-average other emissions, RT, its total emissions are below average i.e. RS + RT < RU + RV. Thus, the percentage of low-income households that have above-average *total* emissions and would, thus, be worse off under TEQs–EAR is likely to be less than the 30% or so with above-average *energy* emissions.

[24] Their work has been usefully extended by Thumim and White (2008).

[25] Dresner and Ekins' analysis is in terms of households. For simplicity, household emissions are here assumed to be proportional to individual emissions.

[26] INDIE emissions are assumed to be proportional to energy emissions. Thus, households with above-average energy emissions will have above-average INDIE emissions. Hence, the suggestion is that the sum of the household's below-average COGS emissions and its above-average energy + INDIE emissions may result in below-average average total emissions.

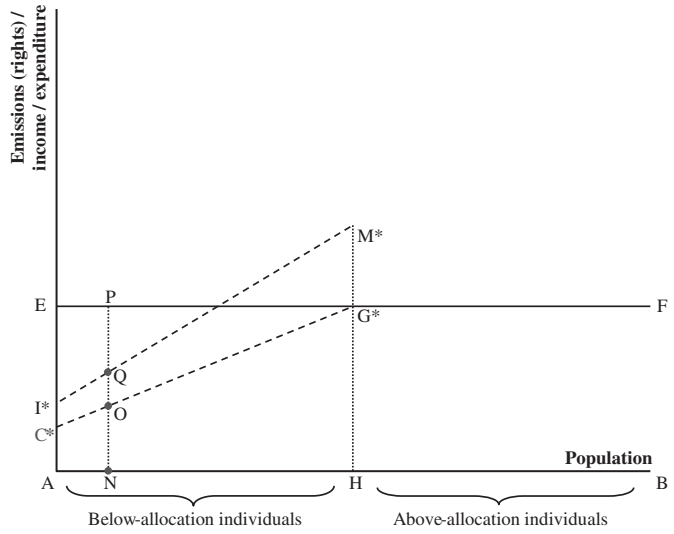

Fig. 5. Below-allocation individuals under TEQs and the proportional scenario. Adapted from Fig. 4 with CD and IJ removed for clarity.

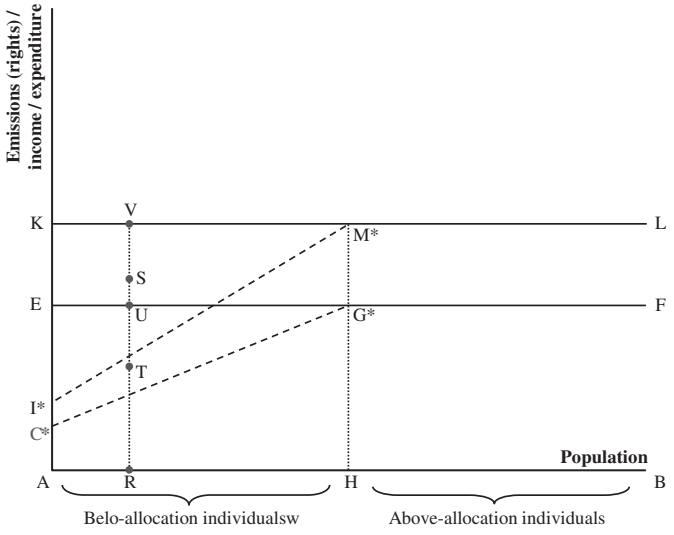

Fig. 6. Example of a low-income household with above-average energy emissions but below-average total emissions.

6. Is an Equal Allocation Fair?

The four instruments discussed in Section 5.2 all allocate emissions rights or auction/tax revenue (henceforth "rights or revenue") on an equal per capita basis and this section explores whether such an allocation is fair. Two arguments for the allocation are set out and assessed from the perspective of the philosophical literature on justice.

6.1. The Commons Argument

The atmosphere acts as a holding bay for greenhouse gases released through human activity prior to their removal by emissions sinks. According to Barnes (2001), this atmospheric holding bay is a "commons", by which he means that it is jointly and equally owned by humanity.

Barnes argues that, because everyone is its equal owner, everyone is entitled to emit equally into it, and because everyone is entitled to emit equally into it, everyone is entitled to an equal share of auction revenue. Barnes' argument for equal revenue is henceforth referred to as the "Commons Argument".[27]

As "everyone" includes children, the Commons Argument implies that, along with adults, children are entitled to equal shares of revenue. Thus, a child born at midnight on 31 December is entitled to an equal share of the revenue allocated the following year. In short, equal ownership of the atmosphere entails ownership of equal quantities of revenue.

Suppose this child's uncle gives her £10,000 on the occasion of her birth. As the child is its rightful owner, the money will be held in trust until she is of an age at which she is deemed competent to use it. Similarly, it can be argued that, as she is the rightful owner of the auction revenue, it too should be held in trust for her. Henceforth, an allocation under which children's revenue is held in trust is referred to as the *Trust Fund* allocation (Table 1).

Although the Commons Argument implies that children should be allocated revenue, Barnes' two proposed C&D allocations are adult-only. Under the *Equal Adult* allocation, adults receive an equal share of auction revenue and, under the *Parental* allocation, all adults receive an equal share with parents receiving the same allocation again for each child (Table 1). But note that, as our child is the rightful owner of the £10,000, the state cannot simply allocate this money to her parents. Similarly, as children are *in principle* the rightful owners of auction revenue, there must *in practice* be sufficiently weighty reasons for the state to abandon the *Trust Fund* allocation for an adult-only allocation. However, Barnes makes no suggestion as to what these reasons might be.

But there is a more fundamental problem with the Commons Argument. For Barnes, an entitlement to equal revenue follows from the fact that the atmosphere is today equally owned. It is today equally owned because, at the outset of humanity, it was equally owned and has remained so ever since. And, following Locke ([1689] 1986), Barnes argues that it was originally equally owned because it was gifted to humanity by God. Unsurprisingly, contemporary philosophers (e.g. Narveson, 1999; Otsuka, 2003) reject theological justifications for original world ownership, and most (e.g. Mack, 2002; Nozick, 1974; Schmidtz, 1997; Steiner, 1994) reject non-theological justifications, holding instead that, in the beginning, the world was originally unowned. Thus, there is little support amongst contemporary philosophers for the Commons Argument (Starkey, 2010).

6.1.1. Cap and Share

The *Cap and Share* website (Cap and Share, 2008) asserts that everyone has an equal right to the "sky commons" whilst Feasta (2008, p. 3) asserts that "everyone on earth" has an equal right to "the limited capacity of the sky to act as an emissions dump". However, unlike Barnes, they offer no explanation as to from where this equal right derives. But Feasta (2008, p. 15) does set out reasons why, in practice, rights should be allocated to adults only, namely that it

> avoids a lot of administrative difficulties, removes opportunities for fraud…and safeguards C&S from the charge that it would encourage people to have more children just to collect the income from the entitlements each birth would bring.[28]

However, Feasta offers no explanation of why these reasons are sufficiently weighty to overturn children's in-principle entitlements to emissions rights.

[27] The Commons Argument can equally be regarded as an argument for equal *emissions rights* (Starkey, 2010).

[28] Such income would go little way toward offsetting the substantial cost of raising a child. In 2009, raising a child to 21 in the UK cost an average of just over £200,000 (Smithers, 2010).

Table 1
Summary of economy-wide schemes.

Name	Actor(s) allocated rights	Allocation method	Free allocation to adults	Rights auctioned (%)	Actor(s) surrendering rights	Emissions covered by surrendered rights	Allocation of auction revenue
TEQs	Adults	Free allocation Market	*Equal adult*[1]: ER_{40}/A	 60	Adults	Energy emissions	 Hypothecated
	Organizations	Market			Organizations	Energy emissions	
PCAs	Adults	Free allocation	*Hillman*[1]: Adults: $>[ER_{42}/(A+C)]$ Parents:$<[ER_{42}/(A+C)]$ per child		Adults	Energy emissions + COGS (public transport) emissions	
		Market		58			Not stated
	Organizations	Market			Organizations (other than public transport)	Energy emissions	
Ayres	Adults	Free allocation Market	*Equal adult:* ER_{100}/A		Adults	Energy emissions	No revenue
					Organizations	Energy emissions	
C&D	Fuel suppliers	Auction		100	Fuel suppliers	Total emissions from fuel combustion	*Trust fund:* Adults + children: $AR/(A+C)$: children's revenue held in trust *Equal Adult:* Adults: AR/A *Parental:* Adults: $AR/(A+C)$ Parents: $AR/(A+C)$ per child
C&S	Adults	Free allocation	*Equal adult:* ER_{100}/A		Fuel suppliers	Total emissions from fuel combustion	No revenue

Abbreviations
ER_{40} = 40% of emissions rights AR = auction revenue A = number of adults in population C = number of children in population
Notes
[1]Based on current UK percentages used (Section 3).

6.2. The Equal Energy Argument

Given the limited philosophical support for the Commons Argument, consider an alternative argument for an equal allocation of rights or revenue relating to adults' energy emissions, namely the "equal" form of the following "Energy Argument".[29]

1. In a just society, adults would be entitled to an (un)equal quantity of energy
2. Energy emissions are proportional to energy consumption
∴ 3. In a just society, adults would be entitled to release an (un)equal quantity of energy emissions
4. In today's less-than-just society, a fair allocation of rights or revenue relating to individual energy emissions is an allocation to adults that reflects the quantity of energy emissions they would be entitled to release in a just society
∴ 5. In today's society, adults are entitled to an (un)equal quantity of rights or revenue relating to their energy emissions (from 3 and 4)

In this Energy Argument and the following discussion, eligible individuals (Section 1) are, for brevity, referred to as adults. Section 7 discusses why eligible individuals will be largely, but perhaps not exclusively, adults.

6.2.1. Premise 2

Imagine a nation in which half the population has an entirely renewable energy supply whilst the energy supplied to the other half is entirely (derived from) fossil fuel. Here it would seem unfair for a PCT scheme to allocate rights equally to all adults for, as renewable energy use produces zero emissions, the first half of the population would not require emissions rights to access energy. Thus, Premise 2 must hold for the "Equal Energy Argument" to be valid. Clearly, it does not hold in the real world but, even assuming it did, some would reject the argument as, based on considerations of *welfare*, they would reject its first premise.

6.2.2. Premise 1

Starkey (2008) discusses five categories of adults that require additional energy to achieve a given level of welfare: those who

- feel the cold and require additional heating to achieve a given level of bodily comfort
- live alone and use more than half the energy used by couples living together
- live in a cold region of a country and require more energy for heating
- live rurally, have less access to public transport and have to travel further to live their lives
- have children in their household and use more energy than those who don't

However, whilst these adults require additional energy to achieve a given level of welfare, theories of justice differ as to whether they are entitled to the additional energy. For example, Starkey argues that, whilst libertarians would hold that they are not, egalitarian liberals would, to varying degrees, hold that they are.[30] A useful starting point in providing a flavor of egalitarian liberal thinking is the distinction drawn by Dworkin (2000, p. 286) between

> a person's *personality*, understood in a broad sense to include his character, convictions, preferences, motives, tastes and ambitions, on the one hand, and his *personal resources* of health, strength and talent on the other (emphasis added).

Feeling the cold is an aspect of *personal resources*, and Starkey argues that both Dworkin and Cohen (1989) would hold that a person who feels the cold should be entitled to additional energy. Conversely, a taste for living rurally is an aspect of *personality*. With regard to energy, this is a type of taste Dworkin describes as "expensive" i.e. one requiring additional resources to achieve a given level of welfare. And over expensive tastes, Dworkin and Cohen famously differ. Consider the following example from Cohen (1989, p. 923).

> Paul loves photography, whilst Fred loves fishing…Prices are such the Fred pursues his pastime with ease while Paul cannot afford to. Paul's life is a lot less pleasant as a result: it might even be true that it has less meaning than Fred's does. I think the egalitarian thing to do is to subsidize Paul's photography…Paul can afford to go fishing as readily as Fred can. Paul's problem is that he hates fishing and, so I am permissibly assuming, could not have helped hating it — it does not suit his natural inclinations. He has a genuinely involuntary expensive taste and I think a commitment to equality implies that he should be helped in the way that people like Paul are helped by subsidized leisure facilities.

Starkey argues that, on this basis, Cohen would support an entitlement to additional energy to those who live rurally as the result of an involuntary taste — which, surely, many do. Likewise, he would support an entitlement to additional energy for those who, on the basis of involuntary tastes, live in cold regions, live alone or have children.[31] However, Dworkin (2004, p. 347) would not, as he holds that

> people should bear the consequences of their choices even when these choices are made out of tastes they have in no way chosen or cultivated.

But whilst their views differ, Cohen and Dworkin would, based on considerations of welfare, endorse an "unequal" version of Premise 1.

6.2.3. Premise 4

Starkey (2008) argues that, for egalitarian liberals, considerations of welfare mean that, in a just society, adults would not only have an entitlement to unequal quantities of energy and energy emissions (Premises 1 and 3) but also to unequal quantities other goods and services and COGS emissions. If, in today's society, a fair allocation of rights or revenue relating to energy emissions and COGS emissions[32] should *reflect* the entitlement in a just society to energy emissions (Premise 4) and to COGS emissions (call this Premise 4*), then the fair allocation of total rights or revenue is an unequal one.[33]

Under "reflective" Premises 4 + 4*, the allocation of rights or revenue relating to energy and other emissions might look like, respectively E´F´BA and K´L´BA (Fig. 7). Under this "reflective" allocation and the proportional scenario, below-allocation adults are better off by E´G*C* + K´M*I*, compared to EG*C* + KM*I* under TEQs–EAR (Fig. 8). However, if the allocation of rights or revenue was inversely proportional to income (the "inverse" allocation), they would be better off still, by E^G*C* + K^M*I* (Fig. 9). With those on low income better off still, the distribution of wealth in society would, from an egalitarian liberal perspective, be closer to that which would obtain in a just society. But does this make the inverse allocation fairer than the reflective allocation? If an allocation is deemed fairer, the closer it moves distribution of wealth to that which would obtain in

[29] Adapted from Starkey (2010).
[30] Egalitarian liberalism is discussed here as it is the foremost approach to justice within the literature.
[31] For a discussion of "Kids as expensive tastes", see Burley (1998, p. 137–141).
[32] If the notion of allocating rights or revenue relating to COGS emissions seems peculiar, note that under, for example, C&D (or C&S), the revenue (or rights) allocated ultimately represent(s) individuals' energy + COGS + INDIE emissions.
[33] It is assumed that the allocation of rights or revenue relating to INDIE emissions is proportion to that relating to energy emissions.

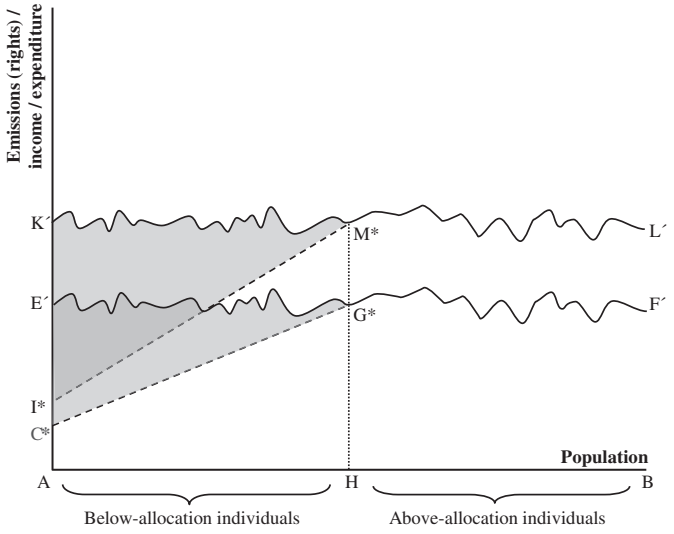

Fig. 7. Amount by which below-allocation individuals are better off under TEQs–EAR and the proportional scenario.

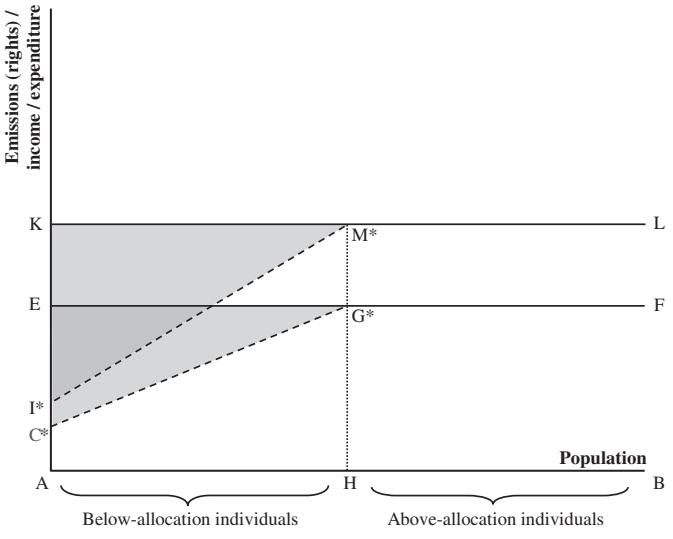

Fig. 8. Amount by which below-allocation individuals are better off under the "reflective" allocation and the proportional scenario.

a just society, then fair allocation becomes simply a roundabout means of egalitarian liberal wealth redistribution. Starkey suggests that egalitarian liberals would not regard such redistribution as the proper aim of rights or revenue allocation but would, instead, regard a fair allocation as one that *reflects* entitlements to emissions in a fair society. In this case, a fair egalitarian liberal allocation would be the reflective allocation.[34]

This discussion around considerations of welfare shows that, from an egalitarian liberal perspective, fairness demands the allocation to adults of 100% of rights or revenue (as under TEQ–EAR) rather than a smaller percentage (as under TEQs). However (in contrast to TEQs–EAR) fairness demands that this allocation of 100% of rights or revenue is an *unequal* one.

6.3. Survey Data on Fairness

Support for an unequal allocation is also found in survey work conducted on PCT. For example, an online survey of over 1000 members of the public conducted by the Institute for Public Policy Research (IPPR) found that 70% (strongly) supported the proposition that the equal per capita allocation under PCT "would be unfair because some people need more carbon credits than others" (Bird and Lockwood, 2009, p. 36). According to Bird and Lockwood (2009, p. 8), this reflects the fact that "most people recognise that people in different situations have different needs for energy use".

6.4. Welfare and Trading Schemes

Section 6 concludes by briefly noting how considerations of welfare can be detected in the thinking of proponents of C&S, PCAs and TEQs.

6.4.1. C&S

Although proponents of C&S argue for the *Equal Adult* allocation, at times they suggest that considerations of welfare make an equal allocation less than completely fair. However, they argue that any lack of fairness should be addressed by measures other than amending the equal allocation. For example, the Cap and Share (2011a) website notes

> Rural populations are more dependent on cars and can say they are a special case. Various groups can argue for special treatment, but this is best done by separate, transparent arrangements, keeping C&S itself simple and easy to understand.

6.4.2. PCAs

Like proponents of C&S, Hillman appears ambivalent about the basis on which to allocate rights. At times he argues that all have equal rights to use the atmosphere and states that allocating equal rights to all is the "most morally defensible option" and "equitable in theory" (Hillman and Fawcett, 2004, p. 118, 126).[35] However, this does not lead him to the *Trust Fund* or, indeed, the *Equal Adult* allocation. Instead, he proposes that all rights should go to adults and that all adults should receive an equal initial allocation, but that parents should receive for each child an additional allocation "somewhat less than that allocated to an adult" in recognition of the additional energy used in households with children (Hillman and Fawcett, 2004, p. 153). This *Hillman* allocation thus differs from the *Parental* allocation under C&D (Table 1).

Considerations of welfare appear to lie behind Hillman's allocation of additional rights to parents and his point that, given their greater energy use, individuals living alone should, *in theory*, be entitled to a greater quantity of emissions rights. However, Hillman rejects such an allocation *in practice* on the grounds of keeping the PCA scheme "as simple…as possible" (Hillman and Fawcett, 2004, p. 127).

6.4.3. TEQs

Fleming (2007, p. 31–32) acknowledges that, from a welfare perspective, the *Equal Adult* allocation is not entirely fair but advocates it because he regards is as being fair enough for practical purposes if supplemented with an increase in child benefit.

7. Defining Eligible Individuals

Eligible individuals are those entitled to an allocation of rights or revenue. Whilst the Commons Argument supports an allocation to

[34] Starkey (2008) argues that egalitarian liberals would hold that, at a minimum, the implementation of an emissions reduction instrument should leave no low-income individual worse off. Thus, if the reflective allocation alone would leave some such individuals worse off, it should be implemented in conjunction with other measures to avoid this happening.

[35] However, Hillman does not state why he thinks all have this equal right.

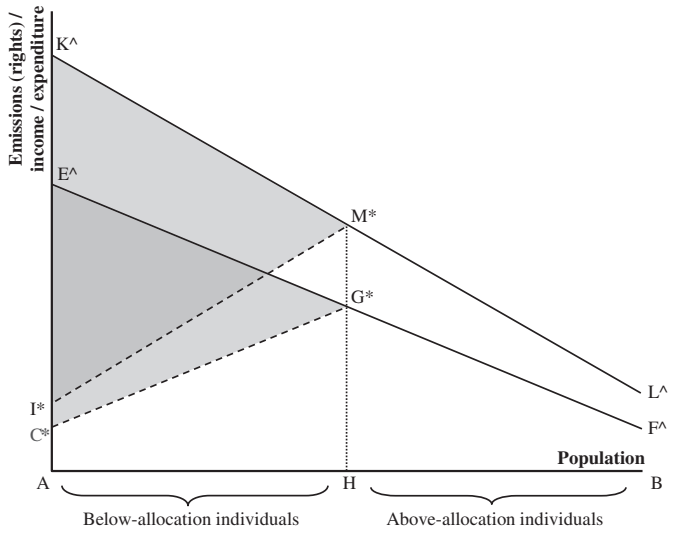

Fig. 9. Amount by which below-allocation individuals are better off under the "inverse" allocation and the proportional scenario.

children, it has little philosophical support. Furthermore, authors such as Raux (2010) and Wadud (2011) who consider allocating to children offer no justification for doing so. But, conversely, proponents of C&D, TEQs and PCAs offer no justification for allocating only to adults. Whilst Feasta's argument for allocating emissions rights only to adults is that doing so avoids administrative difficulties, removes opportunities for fraud and discourages people from having children simply to gain revenue (Section 6.1.1), a different argument is made here. It has been argued (Section 6.2.3) that fairness demands that 100% of rights or revenue – that is, rights or revenue relating to emissions from individuals' consumption of fuel, electricity, other goods and services - are allocated to individuals. And as, roughly speaking, it is adult individuals who purchase these goods and services, it is they, so the argument goes, who should be allocated rights or revenue.

However, to specify eligible individuals more precisely, consider the UK where individuals legally become adults at 18. Nevertheless, at 16, children can legally marry, live independently of their parents, work full-time, enter into contracts to purchase gas and electricity, drive a moped and buy motor fuel. And at 17, children can legally drive a car. Furthermore, children have limited rights to work prior to the age of 16 and so can earn money and purchase a wide range of other goods and services.

Allocating 100% of rights or revenue only to adults would therefore disadvantage (1) those 16 and 17 year-old children who purchase residential energy and/or motor fuel and/or other goods and services and (2) those under-16 who purchase other goods and services. However, given that all energy and almost all other goods and services are purchased by persons of 16 and over, it seems reasonable, for practical purposes, to confine eligibility to this group. But allocating rights or revenue to *all* 16 and 17 year-olds would provide a windfall for the large number who live with their parents and neither purchase residential energy nor motor fuel. Thus, an alternative would be to allocate rights or revenue only to those 16 and 17 year-olds who met certain criteria such as living independently. However, this would increase administrative costs.

Another factor relevant to eligibility is the type of right an individual has to be in a country. Clearly, UK citizens resident in the UK and individuals who have indefinite leave to remain should be eligible for rights or revenue whilst individuals visiting the UK on a six-month visa should not. However, a decision would need to be taken on the eligibility of individuals who fall between these extremes, for example the spouse of a British citizen who has entered the UK on a two-year probationary visa. A further factor is whether an individual's eligibility is absolute. For example, it might be argued that if an individual becomes a long-term resident in an institution (for example a care home or prison), then rights and revenue should no longer go to that individual but to the institution in which they reside.

8. Conclusion

This paper argues that a fair approach to the allocation is one that allocates 100% of rights or revenue and shows that an allocation of around 40% under TEQs and PCAs may, in fact, leave those on low income worse off than prior to their implementation. Under a 100% allocation, arguments have been presented as to why a fair allocation is not an equal per capita allocation. And finally, whatever a fair or equitable allocation might be, it has been noted that the four trading schemes and a carbon tax are all equally capable of delivering it. However, as this paper (and Part 2) also note, this is a fact not fully appreciated by some proponents of (and researchers into) the various schemes. But given this fact, equity cannot be a suitable criterion for "picking a winner" from amongst the schemes and so it is necessary to see if they can be differentiated in terms of their efficiency and/or effectiveness. This is the subject of Part 2.

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