A Carbon tax and the Risk of Inequity

(*An updated and improved version will be made available for the conference*)

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Abstract

This paper aims at clearing up some misunderstandings about the social impacts of carbon taxes that proved to be a decisive obstacle to their further consideration in public debates. It highlights the gap between the cost of a carbon tax reform as it is spontaneously perceived by the taxpayers and the reality of its ultimate consequences: the real impact on households' poverty and inequalities is not mechanically determined by the initial burden of energy on consumption budgets and by the capacity of households to alleviate it, but also depends upon the use made of the tax proceeds and its general macroeconomic impacts. The comparison of five tax-recycling schemes highlights the existence of trade-offs between maximising total consumption, reducing unemployment, maximising the consumption of the low-income classes and reducing income inequality.

Keywords

Carbon tax reform, poverty, inequality

JEL codes

H23, Q52

Introduction

The recent withdrawal of the carbon tax proposal by the French government (March 2010)[1] is the latest failure of a policy instrument though consistently prescribed as an efficient way to mitigate climate change (since at least Pearce, 1991). There were admittedly some success stories (Finland, 1990 ; Sweden, 1991 ; Italy and Germany, 1999 ; Switzerland, 2008)[2], but also a long list of rejections.[3] On top of specific reasons of their own, these failed attempts seem to have faced similar oppositions, based on two major arguments: that of competitiveness distortion, and that of a negative impact on the poorest households (Ekins, 1999). However well-grounded these fears, it is surprising to observe that they were systematically used to reject the carbon tax, rather than treated as surmountable obstacles that merely required careful consideration in its implementation—as demonstrated at length by a large body of economic literature.[4]

The rejection of the *Conseil Constitutionnel* is symptomatic of this stranglehold: pressed to give back to households the tax proceeds in order not to be blamed for unfairness, the government transmitted the new tax burden to sectors that are not carbon intensive - the most carbon intensive industries benefiting for the time from free allowances within the EU ETS system; indeed, this system will not be challenged since it is the result of a long historical support from these companies that strive to maintain profitability, which would have been strongly affected by a 'first ton emitted' tax[5].

It is because equity issues have both played an important role in the French carbon tax's rejection and led to misunderstandings that we try here to show how the social impact of carbon taxation[6] is linked to the use made of the tax proceeds. We will do this by evaluating the performance of several long-term revenue recycling schemes (sections III to V) this after a brief return to the source of the gap between their

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[1] A first proposal was rejected by the *Conseil Consitutionnel* on December 28, 2009. The revision of this proposal was abandoned as a collateral damage of the setback of the governmental majority in the European elections of March 2010.

[2] The UK Road Fuel Duty Escalator (1993-1999) could be added to this list.

[3] Carbon Tax of the French *Mission Interministérielle de l'Effet de Serre* (1990), Carbon-Energy Tax of the European Union (1992), BTU tax of the Clinton Administration (1993), '*écotaxe*' of the Jospin government in France again (1999), projects in Australia and New Zealand, *etc*.

[4] For reviews covering a long historical period, see IPCC (1995) and OECD (2003).

[5] It is in fact their stock market value which weakens these firms, more than a loss of competitiveness due to asymmetric carbon constraints between them and their competitors.

[6] That is to say, when its cost is borne disproportionately by the most vulnerable or when the richest households receive a disproportionate share of its economic benefit.

immediately perceived and final costs (section I) and a presentation of the modelling framework used (section II).

I. Perceived *versus* real impacts: reasons for the gap

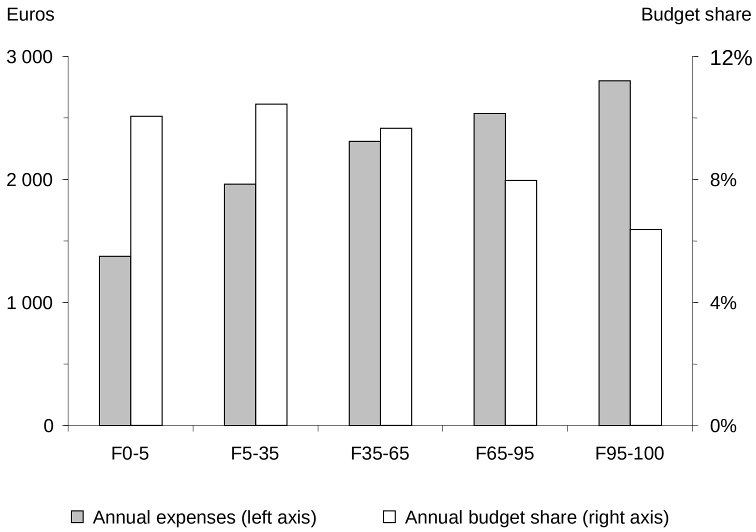
The direct impact of a carbon tax on the welfare of households is regressive: higher-income households admittedly consume more energy and are bound to pay more carbon tax in absolute terms; but the budget share of energy is larger for the lower-income households.[7] Evidence for this can be gleaned in the French 2001 *Budget des Familles* (hereafter BDF) survey, which covers a cross-section of 10 305 households (INSEE, 2001): households in the top living standard twentile[8] spend on average two times more on energy than those in the bottom one, but the share of their budget devoted to energy is 30% lower (Figure 1).[9]

It must be stressed that the energy budget shares vary substantially within each of the aggregated fractiles of Figure 1, as a closer look at the extensive BDF data reveals (Figure 2). Indeed, multiple factors beyond sheer living standard determine these shares and thus vulnerability to energy prices (local climate, local density, availability of public transport alternatives, commuting distance, housing type, heating mode, *etc*). Some of these factors have become critical, notably those connected to the urban sprawl triggered by decades of low energy prices and steadily rising housing prices, and the induced personal car-dominated lifestyle—hence the highest budget share of the French 'lower class' (twentiles 2 to 7), which is more motorised than the bottom twentile (80% *vs.* 65%).

[7] At least in most OECD countries, although Bosquet (2000) points to exceptions and Hassett *et al.* (2007) show that conclusions differ whether current consumption or current income is used as wealth indicator. Scarcer research on developing countries reveals a loose correlation, if not an inverse relationship (Yusuf and Resosudarmo 2007).

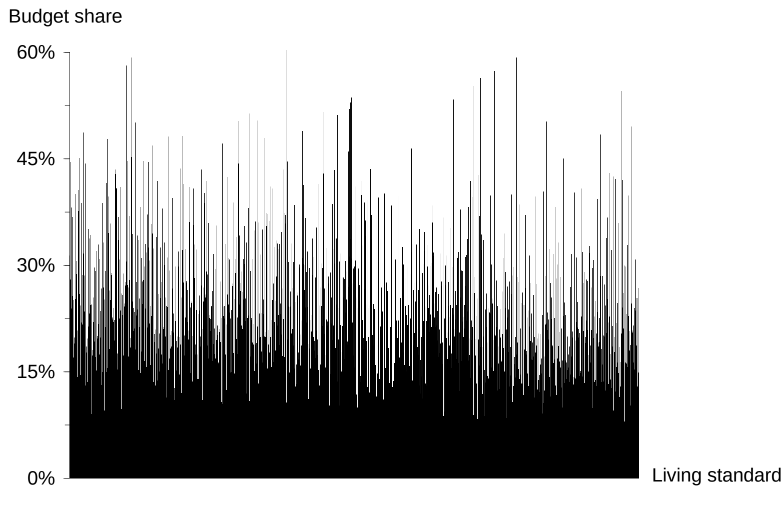
[8] Here and throughout this paper living standard is understood as income *per* OECD consumption unit (CU, 1 CU for the first adult, 0.5 CU for any other person above 14 and 0.3 CU *per* children below 14). The tax is less regressive with *per capita* income (Grainger and Kolstad, 2010) or with another approximation of the concept of "permanent income" (Hassett *et al.*, 2007).

[9] The latter ratio is confirmed by the ADEME for 2006 (ADEME, 2008).



F#-# : living standard fractile (F0-5: the 5% poorest households, *etc.*)
Source: INSEE (2001), authors' calculation

Figure 1 **Average annual energy expenditure and budget share *per* household for 5 living standard classes, 2001 France**



Source INSEE (2001), authors' calculation

Figure 2 **Budget share of energy expenses *per* living standard, 10 305 French households, 2001**

The focus of this paper will however remain on living standard classes only, postponing to further research the exploration of these other dimensions of energy vulnerability—but for purposes of real policy design they cannot be ignored; Therefore, we will invoked them when comparing the performances of three compensation schemes (section V). Notwithstanding such complexity, the picture given by the average budget shares (Figure 1) is indeed easily conveyed in public debates. It has however the inconvenience of concealing the gap between the costs immediately perceived, and those eventually supported, as it does not account for:

- *Responses to price signals*, in the form of change in the energy mix and the energy efficiency of equipments and buildings, modal shifts in transport, *etc*. Accounting for price elasticities tends to reduce the magnitude of distributional effects (West and Williams, 2004).

- *Propagation effects* on the rest of the economy: the increase of non-energy prices through the input-output matrix tend to increase the regressive impact of the tax (Wier *et al.*, 2005);

- *Rebating of the tax proceeds* to the economy: tax revenues may be used to cancel out or reverse the direct regressive impacts (Metcalf, 2007). More importantly, general equilibrium effects are such that those paying the tax are not necessarily those bearing its ultimate burden. Consequently, all things being equal (employment, income, debt, *etc*.), assessment is bound to be misleading (Proost and van Regemorter, 1995).

On this last point, there is a longstanding agreement that a carbon tax should replace the most distortive pre-existing taxes (IPCC, 1995, section 8.2.3.3), in many instances those weighing on labour. But there is also a controversy over the possibility of a "strong double dividend" (Goulder, 1994) associating lower carbon emissions and higher aggregate welfare. The terms of this controversy are however easily reconciled:

- In a closed economy with only one production factor (labour) and under perfect competition, payroll tax recycling does not induce a strong double dividend because taxing consumption is equivalent to taxing the income that allows for it; the carbon tax thus weighs on labour as a source of income, same as the levy it is replacing (Bovenberg and De Mooij, 1994a, 1994b; Goulder, 1994).[10]

- The 'strong' double dividend potential is less elusive when acknowledging that the carbon tax burden is not entirely borne by labour or the national productive capital: it also weighs on non-wage income (financial and property rents, transfer revenues), as well as on the oil and gas rent of exporting countries (Goulder, 1995; Ligthart, 1998). In total, payroll tax recycling can decrease the levy on national production and net gains can occur, all the more so as the labour market is rigid

[10] In addition the tax distorts the market for consumer goods. Its overall impact is thus a welfare loss.

(Carraro and Soubeyran, 1996). This explains how applied European research focused on this recycling option demonstrates its superiority to other tax adjustments (IPCC, 2001, section 8.2.2.1).

Last but not least, notwithstanding their sign the induced welfare variations call for distinguishing between the impact of a carbon tax reform on income distribution, and its particular consequences for the poorest households: a reform improving income distribution could reduce the welfare of the poorest households if it induces GDP losses; conversely, a reform that increases inequalities could improve the absolute situation of the poorest households if it triggers a strong double dividend.

Sections III to V below aim at clarifying these issues with numerical analyses produced by IMACLIM-S, a modelling tool that section II describes.

II. IMACLIM-S, a hybrid model with income classes

The IMACLIM-S model (Ghersi and Hourcade, 2006 ; Ghersi *et al.*, 2009) is a computable general equilibrium model devoted to carbon policy analysis through comparative statics (Samuelson, 1947).[11] The version applied in this paper is an open-economy version distinguishing four types of agents (households disaggregated into twenty living standard classes, firms, public administrations, and the 'rest of the world') and four productions (crude oil, automotive fuels, other energies for housing and a composite good aggregating all non-energy goods and services).[12]

IMACLIM-S is a 'hybrid' model in the sense that it pictures energy volumes that are not deduced from national accounts statistics and a single energy price hypothesis, but rather result from an effort to harmonise these macroeconomic data with energy balances and energy prices statistics in the reference year. This hybridisation of the input-output table facilitates the integration of some engineering expertise about technical flexibilities at a given time horizon. In particular, energy efficiency improvements of equipments and infrastructures used by both the producer and the consumer are bounded by exogenous asymptotes.[13] As a result, the model exhibits price elasticities that gradually decrease as the relative energy prices increase (rather than constant elasticities).

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[11] IMACLIM also exists in a dynamic, recursive version IMACLIM-R (Sassi *et al.*, 2010).

[12] The energy mix heterogeneity of automotive fuels and the aggregate of residential energy is accounted for through agent-specific prices and CO_2 contents.

[13] This specification accounts for inertia in the installed capacity (the 'putty-clay' hypothesis of Johansen, 1959) and sets boundaries to the production frontier at the modelled temporal horizon. This defines an *innovation possibility curve* in the sense of Ahmad (1966) (*cf.* Ghersi and Hourcade, 2006), that synthesises various elements of technical controversy: limits to technical change, to the replacement of the installed capacity, and to structural change in the economy.

The income flow associated with the flow of goods starts with the remuneration of production factors plus net payments from/to the rest of the world. It continues with distribution operations orchestrated by the public administration between the four categories of agents: taxes (payroll taxes, VAT, TIPP—interior tax on petroleum products, corporate tax, income tax, *etc.*) and transfers (unemployment benefits, pensions, *etc.*). Once they have made their consumption and investment choices, agents lend or borrow on financial markets depending on whether their exhibit positive or negative savings. This affects their financial positions and the associated income flows (debt services, interest payments).

The model is calibrated on 2004 data (INSEE, 2004; IEA, 2007). Its formal structure, reference tables and parameter values are available online.[14]

Determinants of the macroeconomic impacts

The comparative statics analysis amounts to distort the 'image' of the no-policy economy by an external shock—the carbon tax. The particulars of this distortion are induced by the interaction of five sets of assumptions defining:

- *The adaptation of the productive system*, through the adjustment of inputs (labour, capital, intermediate consumptions) to the variation of their relative prices, the evolution of total factor productivity (an endogenous technical progress coefficient is correlated to cumulated investment), and the influence of static decreasing returns.

- *The reaction of consumers*, embodied in price and income elasticities for the two final energy uses (automotive fuels and residential energy).[15]

- *The rigidity of the labour market*, formalised by a wage curve that describes a negative correlation between unemployment and the average net wage (Blanchflower and Oswald, 2005).

- *The impact on international trade*: absolute exports and the relative contribution of imports to resources are elastic to terms of trade that evolve according to the cost of domestic production, facing constant international prices (the international composite good is the *numéraire* of the model).

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[14] http://www.imaclim.centre-cired.fr/spip.php?article241&lang=en

[15] At the no-tax equilibrium they are supposed to be identical for all household classes (respectively -0.39 and 0.50 for fuel, -0.03 and 0.74 for residential energy), but decrease with energy consumption depending on the specific position of each class related to the common asymptote. Class-specific equilibrium values are the focus of ongoing research and will be introduced in further publications.

- *Public budget constraints*: the ratio of public expenditures to GDP is assumed constant; social transfers (*per capita* unemployment benefits, pensions, and other transfers) are indexed on the average net wage.

The degree of rigidity of the labour market is a particularly crucial assumption. Calibrated on 2004 France, the no-tax economy is modelled as a situation of structural underemployment with limited wage flexibility relative to international prices. This reflects both the strong competitiveness constraints specific to the French-European Union context, and the regulated nature of the French labour market. On one hand it forces a wage moderation that sets limits on the energy price propagation effects and amplifies a trade-off in favour of labour; on the other hand it disconnects wages from domestic prices, and thus does not exclude substantial real wage variations.[16]

Assuming constant saving rates and the adjustment of fixed capital formation on the demand addressed to the production system, the model is 'closed' by computing the capital flows that balance current accounts. Equilibrium is determined by the simultaneous adjustment of the volumes traded with the rest of the world, the domestic prices, the level of activity and the interest rates.

The compact nature of IMACLIM-S and its comparative statics principle make it especially suited for conducting parametric sensitivity tests, as was done in Combet *et al.* (2010). Such tests are however outside the scope of this paper, which will limit itself to the central set of assumptions described above (and fully referenced online).[17]

Determinants of the distributional impacts

Starting from the *BDF* 2001 data, distributional effects are analysed on 20 income classes characterised by specific structures of income and expenditure, savings rates and direct tax rates, and net financial positions. Therefore they result from the heterogeneity of:

- *The energy saving potential of households*; the closer to their basic needs, the smaller the ability of households to alleviate their tax burden by reducing their energy consumptions.[18]

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[16] The non-indexing of wages on prices is a feature shared by several French macroeconomic models, as Amadeus, or Mimosa from the CEPII-OFCE, based on econometric studies (Heyer *et al.*, 2000). For the analysis of alternate assumptions *cf.* Combet *et al.* (2010).

[17] http://www.imaclim.centre-cired.fr/spip.php?article241&lang=en

[18] Asymptotes are identical for all classes and set, on a *per capita* basis, at 80% of the energy consumption of that twentile for which it is the lowest.

- *The sensitivity of income structures* to variations of wages and the interest rate, given that *per capita* social transfers are indexed on net wages.

- *Situations on the labour market*: aggregate employment variations are distributed among classes according to their specific unemployment and payroll tax rates; in addition, the income shift induced by the transition from unemployment to activity or activity to unemployment is specific to each class.

Carbon tax reforms: counterfactual 2004 Frances

The simulated tax reforms differ only in the way in which tax proceeds are recycled. The carbon tax common to all reforms is assumed unilateral, without border adjustment measures, imposed on the carbon content of all fossil fuel sales. It is supposed to have grown smoothly since 1984, leading to 'counterfactual 2004 Frances' adjusted to the 20-year reform.

This long term perspective justifies analysing the impact of a substantial €300 *per* tonne of CO_2 (/tCO_2) tax, with the advantage of emphasizing that the social cost of a carbon tax is not equal to the sum of abatement costs it entails, but depends first and foremost on the use of its revenues. The 'gross' signal (or '*ex ante*' signal *i.e.* excluding macroeconomic dynamics and changes in the energy mix) triggers fuel price increases of 139% for firms and 103% for consumers, and price increases of 135% for firms and 68% for consumers, for other energy uses.[19]

For the sake of clarity, the modelled twentiles are aggregated in five classes to report results: the 'poor' (bottom twentile), a 'lower class' (twentiles 2 to 7), a 'middle class' (twentiles 8 to 13), an 'upper class' (twentiles 14 to 19), and the 'rich' (top twentile). Living standard variations are measured by an indicator of effective consumption that aggregates, *via* a Fisher index, composite consumption, energy services[20] and individualised public good consumption (public healthcare, social housing, *etc.*).[21]

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[19] Despite the high level of pre-existing taxes on fuels (TIPP), the signal on fuel prices is stronger than that on other energies because the latter include electricity, which is not taxed (no direct emissions).

[20] Over 20 years, a reform of the magnitude envisaged cannot but lead to energy efficiency improvements, *i.e.* higher energy services *per* energy unit. To account for these improvements modelling results receive an *ex post* adjustment of a deliberately conservative 3.8% (*i.e.* real consumption variations are reported with energy consumptions 3.8% higher than simulated).

[21] We deliberately refrain from imposing any functional form to utility. The rate of decrease of the marginal utility of consumption (the impact of marginal variations of the effective consumption on welfare at different consumption levels) is left to the reader's appreciation.

III. The gross effect of a carbon tax on poverty and inequality

This third section provides a first set of simulations that compare the effects of a carbon tax without any specific provision to correct its distributional impacts.[22] Two contrasted uses of the proceeds are explored:

- A first option uses them to decrease the public debt, with a view to represent the common perception of a fiscal burden with no compensation on disposable income.
- A second option devotes them to a decrease of payroll taxes, under the constraint of a constant public debt to GDP ratio, and is therefore neutral as regards public budgets and intergenerational equity.[23]

These contrasted assumptions turn out to increase inequality for specific reasons, but do so in very different macroeconomic contexts.

Impact on growth and employment

The most important result that emerges from the comparison of these two reforms (Table 1) is that comparable levels of emission reduction (34.1% and 38.5%)[24] are achieved under opposite variations of GDP (-6.5% *vs.* +1.9%), employment (-5.7% *vs.* +3.5%) and effective consumption (-9.5% *vs.* +1.5%). The impact of the first reform is quite intuitive, since the sharp drop in public debt (-92%) implies a wealth transfer out of the national economy; that of the second reform is less obvious, as it corresponds to a strong form of double dividend.

[22] We do not simulate a lump-sum recycling option (in the strict sense of a rebate to each agent of the exact amount of tax paid), which provides a useful reference point on a theoretical point of view, but is an artefact that does not translate into any plausible policy.

[23] The double dividend literature, often assuming a constant absolute level of the tax burden, does not sufficiently highlight the fact that budget neutrality may be interpreted in different ways, which lead to different trade-offs between consumption and public debt reduction, *i.e.* different distributions of the costs of climate policy between present and future generations (Combet *et al.*, 2010).

[24] The difference is primarily due to a volume effect, as inferred from comparable ratios of tons of CO_2 emissions *per* euro of GDP: 0.164 *vs.* 0.161 (0.248 without tax).

Use of tax proceeds (€300/tCO_2)	Lower public debt	Lower payroll taxes
Total CO_2 emissions	-38,5%	-34,1%
Real gross domestic product	-6,5%*	+1,9%
Employment (full time equivalents)	-5,7%**	+3,5%
Households' effective consumption***	-9,5%	+1,5%
Public debt to GDP ratio	-92,0%	id.
Producer price, composite good****	-0,6%	-1,0%
Labour intensity, composite good	+0,8%	+1,4%
Real composite good exports	+0,4%	+0,6%
Real composite good imports (share of domestic resources)	-0,5%	-0,9%
Real public consumption	-3,1%	+5,4%
Real investment	-6,9%	+1,9%

* -6.5% GDP corresponds to a decrease of 0.34 points of the annual growth rate over 20 years. Assuming a 2% annual growth rate in the absence of reform this amounts to a *ca* four-year lag in growth.
** -5.7% employment translates to 1.4 million less jobs and a 5.2 point increase of the unemployment rate to 14.8%.
*** Fisher quantity index aggregating composite consumption, energy consumption and individualised government expenditures, assuming a tax-induced 3.8% energy efficiency increase of households' equipments.
**** Relative to the price of the international variety of the composite good.

Table 1 Aggregate impacts of a €300/tCO_2 tax for 2 contrasted uses of the tax proceeds

The decomposition of the price variation of the composite good helps to understand the mechanisms accounting for such different outcomes (Table 2). Despite a 1.6% increase in the cost of energy inputs, this price declines in both cases, but for very different reasons: when public debt is lowered, a lower output alleviates the pressure of decreasing returns to scale, and, through increased unemployment, induces lower net wages; when payroll taxes are lowered the cut in costs does more than compensate the direct increase of energy costs and the induced increase of net wages.

Use of tax proceeds (€300/tCO_2)	Lower public debt	Lower payroll taxes
Producer price, composite good	-0,6%	-1,0%
Decreasing returns to scale & technical progress	-0,3%	+0,1%
Cost of energy	+1,6%	+1,6%
Net wages	-1,6%	+1,5%
Payroll taxes	id.	-3,6%
Other components*	-0,3%	-0,6%

* The contributions of the other components and the price decomposition methodology are given in the appendix online: http://www.imaclim.centre-cired.fr/spip.php?article241&lang=en

Table 2 Sources of variation of the composite producer price

The 'deflation circle' triggered by the first reform can thus be summed up as follows: higher energy expenses cut into domestic demand, which contracts activity and increases unemployment; this exerts a downward pressure on wages that further decreases the purchasing power of households. The mechanism, slowed down by a small increase in the labour intensity of production (+0.8%), continues until the drop in domestic prices induces enough gains from trade (increased imports, +0.4%, decreased share of imports, -0.5%) to compensate it.

The importance of recycling tax proceeds into lower payroll taxes is therefore made clear: by blocking the spread of rising production costs it preserves the competitiveness of domestic production, while raising labour intensity (+1.4%). The consecutive decrease of unemployment allows household demand to rise, which initiates a virtuous circle up to 1.5%, 5.4% and 1.9% growths in household consumption, government expenditures, and investment.[25] The counterbalancing force is provided by an upward pressure on wages that stabilise at +1.5%—and indeed contributes to increasing the purchasing power of households.

This performance of the lower payroll tax option is consistent with theoretical analysis: the cost of the reform is reduced if the tax is substituted to a particularly distortive pre-existing levy; it can be negative if this replacement reduces the 'deadweight loss' of the overall tax system.

[25] The engagement of this virtuous circle is certainly not systematic. It depends on a set of parameters and assumptions regarding mainly the labour market and the proportion of the payroll tax rebate that concretises into lower prices, rather than higher wages or profits. The size of the dividend to which it leads also depends on the substitution possibilities of the producer and the consumer, on the sensitivity of trade balances to the terms of trade and on the set of rules governing public budgets. Combet *et al.* (2010) explore some of these issues.

Ultimate distributional effects: multiple channels at work

Both uses of the tax proceeds turn out to exacerbate income inequality (Table 3). The share of the poor and the lower class in household income decreases slightly (-0.01 to -0.11 points) and their consumption is either more reduced (-10.1% and -9.9%) or less boosted (+1.1% and +1.2%) than that of the upper class or the rich. A Gini index measure of distribution indicates that the lower-debt option induces less consumption inequality, but it brings down the consumption of the poor by 10.1% while the lower-payroll-tax option increases it by 1.1%—which points out at potential trade-offs between efficiency (growth) and equity (income distribution).

	Share of disposable income (percentage point variation)		Effective consumption*	
	Lower public debt	Lower payroll taxes	Lower public debt	Lower payroll taxes
Poor (F0-5)	-0.02	-0.01	-10.1%	+1.1%
Lower class (F5-35)	-0.11	-0.02	-9.9%	+1.2%
Middle class (F35-65)	+0.04	-0.11	-9.7%	+0.9%
Upper class (F65-95)	+0.13	-0.05	-9.1%	+1.8%
Rich (F95-100)	-0.04	+0.19	-9.2%	+3.8%
Gini index			+1.3%	+2.0%

F#-# : income classes (F0-5 : the 5% poorest *etc.*)
* Fisher quantity index aggregating composite consumption, energy consumption and individualised government expenditures, assuming a tax-induced 3.8% energy efficiency increase of households' equipments.

Table 3 Distributional impacts of a €300/tCO_2 tax for two contrasted uses of the tax proceeds

The basic reason why both reforms increase inequality is that they both raise the energy expenses of the poor substantially more than those of the rich, by 11 percentage points in one instance and by 6 in the other (Table 4).[26] This simply reflects the fact that poor households, who are initially closer to their basic needs of energy services, have an elasticity of substitution between energy and the composite good lower than that of rich households.

[26] The reader shall notice that this is not true for residential energy in the case of lower payroll taxes. The underlining cause is the existence of some 'rebound effects': as rich households become substantially richer than the other classes they do increase more their energy consumption in housing and finally assume a higher bill.

	Energy expenses			Unemployment (percentage point variation)	Disposable income
	Fuel	Residential	Total		
Lower public debt					
Poor (F0-5)	+81.6%	+61.0%	+69.8%	+21.0	-7.2%
Lower class (F5-35)	+71.2%	+61.4%	+66.0%	+10.6	-6.7%
Middle class (F35-65)	+62.2%	+61.3%	+61.8%	+3.8	-6.0%
Upper class (F65-95)	+60.0%	+60.9%	+60.4%	+2.4	-5.8%
Rich (F95-100)	+58.7%	+59.6%	+59.1%	+2.0	-6.4%
Lower payroll taxes					
Poor (F0-5)	+84.2%	+73.9%	+78.3%	-12.2	+5.4%
Lower class (F5-35)	+76.1%	+74.2%	+75.1%	-6.8	+5.7%
Middle class (F35-65)	+69.0%	+73.8%	+71.2%	-2.5	+5.4%
Upper class (F65-95)	+67.5%	+74.1%	+70.5%	-1.2	+5.7%
Rich (F95-100)	+68.0%	+76.1%	+72.0%	-0.9	+7.3%

F#-#: income classes (F0-5: the 5% poorest, *etc.*)

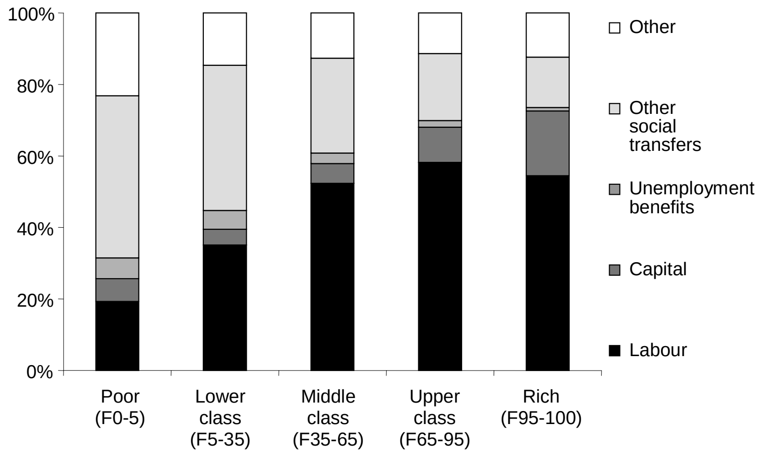
Table 4 Sources of the distributional impacts of a €300/tCO_2 tax for 2 contrasted uses of the tax proceeds

But the ultimate income distribution is also very sensitive to changes in the level of activity and therefore to the use made of the revenue; this sensitivity stems from two main factors:

- The heterogeneity of the situation of households on the labour market. On the one hand, poor and lower classes have already got large payroll taxes cuts targeted lower wages and this limits the effect on employment of the new reduction.; on the other hand the two same classes are much more sensitive to activity increases because their *ex-ante* unemployment rate is much higher than that of other classes (respectively 39% and 21%, *vs.* 4.4% and 3.7% for the upper class and the rich). Then unemployment benefits cover the lower incomes more than the higher, which implies that the income of the richer classes varies more with the shift of status from activity to unemployment. In total the sum of the labour income and unemployment benefits varies more for the bottom twentile than for the top one (-18.3% and +13.5% against -6.9% and +5.8%).

- The diversity of the non-labour income sources by class (Figure 3). Capital income, positively correlated to the living standard, is growing faster than labour income in the lower-payroll-tax option (+14.5% *vs.* +7.8%), or is declining less than it in the lower-debt option (-3.8% against -9.7%) (Table 5).

These results obviously depend on the rules adopted on the ratios of government expenditure to GDP, public investment to GDP, and the indexation of social transfers. The important point is that revenues do not fluctuate in a homothetic way with GDP. In fact the impact of the lower-payroll-tax option echoes the experience of the past twenty years of a positive correlation between activity, property income and financial assets returns. In the case of growth, property income rises sharply due to the improvement of the debt position of households in the context of rising interest rates. This effect is not symmetric in the case of contraction of the economic activity because the decrease in interest rates is restrained by the fact that the debt repayment makes capital scarcer.



Source: INSEE (2001), authors' calculation
'Other' sources are mostly the rents and imputed rents of landowners; they also include direct transfers from other households, non-profit organizations, corporations and the rest of the world.

Figure 3 Sources of income by class, France, 2004

Sources of income	Nominal Changes Lower public debt	Lower payroll taxes
Labour income	-9,7%	+7,8%
Capital income	-3,8%	+14,5%
Unemployment benefits	+47,5%	-29,8%
Other social transfers	-4,2%	+4,2%
Other income	-6,4%	+1,9%

Table 5 Variations in household income by source induced by a €300/tCO_2 tax for two contrasted uses of tax proceeds

IV. Impact on poverty and inequality of a carbon tax fully rebated to households

The results of the previous section explain why the recycling in lower payroll taxes was advocated by the Rocard commission, specifically set up to produce guidance on the French reform. However, the ensuing political discussions quickly overlooked it to focus, for the sake of equity, on a 'green check' rebating scheme, which consisted in rebating to households the amount of tax they had paid on an equal basis (only taking into account different household's location and size).

This section explores an extreme case of the 'green check' option, where all tax proceeds, including those levied on firms, are rebated to households in even shares.[27] Compared with the lower-payroll-tax option, this 'extended-green-check' option induces similar emission reductions (-34.8% *vs.* -34.1%)[28], but again leads to contrasted socio-economic impacts (Table 6).

[27] Our runs make the explicit assumption of a rebate taking the form of some lump-sum amount *per* consumption unit (*cf.* footnote 8).

[28] Rebating the tax proceeds to households rather than in lower payroll taxes induces a rebound effect in energy consumption and limits the technical and structural change towards less energy-intensive production. This accounts for slightly higher emissions.

Recycling		Lower payroll taxes	Extended green check
Total CO_2 emissions		-34.1%	-34.8%
Real gross domestic product		+1.9%	-0.7%
Effective consumption (aggregate)*		+1.5%	+0.4%
Total employment (full time equivalent)		+3.5%	+0.3%
Real investment		+1.9%	-0.7%
Producer price of the composite good		-1.0%	+3.7%
Labour intensity of the composite good		+1.4%	+0.8%
Effective consumption*	Poor (F0-5)	+1.3%	+5.1%
	Lower class (F5-35)	+1.4%	+2.7%
	Middle class (F35-65)	+1.1%	+0.2%
	Upper class (F65-95)	+2.0%	-0.9%
	Rich (F95-100)	+4.0%	-0.6%
Share of household disposable income (points variation)	Poor (F0-5)	-0.01	+0.12
	Lower class (F5-35)	-0.02	+0.69
	Middle class (F35-65)	-0.11	+0.15
	Upper class (F65-95)	-0.05	-0.70
	Rich (F95-100)	+0.19	-0.25
	Gini index	+2.0%	-5.5%

F#-#: income classes (F0-5: the 5% poorest, *etc.*)
* Fisher quantity index aggregating composite consumption, energy consumption and individualised government expenditures, accounting for a tax-induced 3.8% energy efficiency increase of households' equipments.

Table 6 Macroeconomic and distributional impacts of a €300/tCO_2 tax recycled in lower payroll taxes *vs.* an extended green check

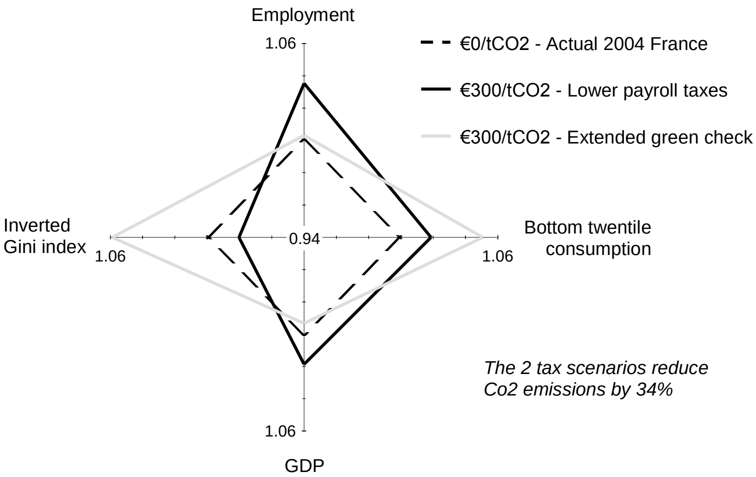
As expected the extended green check is strongly progressive: the cumulated share of the poor, the lower and the middle class in disposable income increases by 0.96 points. This results in a significant reduction of consumption inequality, as testified by a 5.5% decrease of the Gini index, and allows the poor and the lower class to significantly increase their consumption (+5.1% and +2.7%). But the consumption of the upper class and the rich is slightly reduced (-0.6% to -0.9%). Indeed, the average poor household pays €682 of carbon tax but receives a green check of €2,619—the balance amounting to 11% of its initial consumption budget; by contrast the average rich household benefits from a €1,060 balance that amounts to only 1.6% of its budget.

However the extended green check leads to a lower economic growth (-0.7%), reduced employment gains (+0.3% *vs.* +3.5% in the lower-payroll-tax option) and a contraction of investment (-0.7%). These adverse effects are mainly the result of rising production costs that spread throughout the economy, as the higher energy costs are not counterbalanced by lower labour costs. The rising production costs induce simultaneously a degradation of the terms of trade, and a decrease of the purchasing power of households. This translates into a depressed demand for domestic products, which causes unemployment to rise, which in turn further degrades the purchasing power of households. The vicious circle thus engaged is checked by the support to consumption that is implicit in the transfer to consumers of the tax payments of the producers. The overall propensity to consume also increases due to a strongly progressive income redistribution (a ‘Kaldorian’ effect). But this support is not strong enough to cancel the impact on competitiveness and investment (-0.7%).

The two recycling schemes ultimately outline an equity-efficiency dilemma, which is conveniently represented on a four-dimensional diagram (Figure 4):

- on the north-south axis, two efficiency criteria: employment and GDP;
- on the east-west axis, two equity criteria: the level of consumption of the poor (first twentile) and the inverse of the Gini index (to produce an indicator that increases as the consumption distribution becomes more equal).

In this diagram the historical situation of 2004 is represented by a dashed black diamond with an index of 1 on the four criteria.



Variations of the consumption of the bottom twentile and GDP are in real terms. The inverted Gini index is computed on consumption rather than income.

Figure 4 The equity-efficiency dilemma of a carbon tax reform

The stakes are thus made clear: recycling a €300/tCO_2 tax in lower payroll taxes does not benefit equity but is far more efficient than an extended green check scheme (870,000 more jobs and 2.6 percentage points more GDP in 2004). The paramount importance of the recycling scheme on the distributional impact of the reform is also duly highlighted.

V. Equity and efficiency: room for manoeuvre and compromises

This last section considers three proposals of compromise between economic efficiency and equity. Each of these proposals includes a system of compensation to households of the equity impacts, which preserves the environmental efficiency of price signals. Funds that are not used to finance this compensation are recycled in lower payroll taxes—under the maintained constraint of a constant public debt to GDP ratio. The proposals are the following:

- A restricted green check option that rebates to households the tax levied on their energy expenses only,[29] on a fix *per*-consumption-unit basis. The carbon tax levied on production is thus recycled in lower payroll taxes. This '*mixed recycling*' option has the advantage of circumventing the dispute over the sharing of the tax proceeds between households and firms.

- A *generalised tax credit* option that rebates to all households a lump sum corresponding to the tax levied on basic energy needs estimated at 56% of the before-tax energy consumption of the bottom twentile.[30] This earmarks a substantially higher share of the tax proceeds for payroll tax reduction.

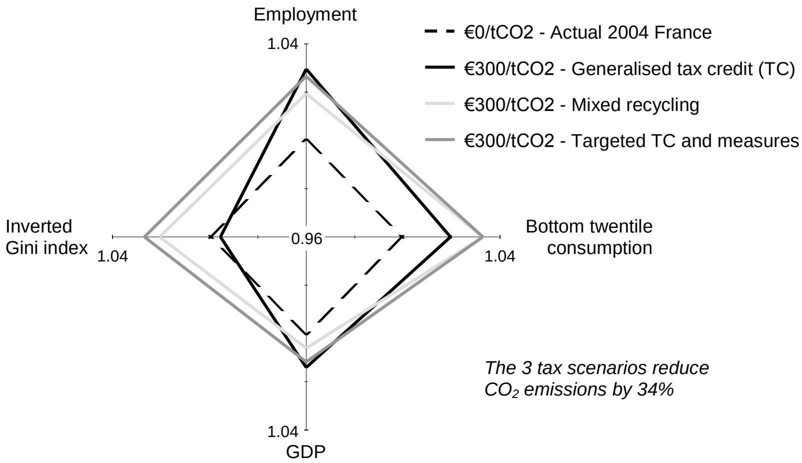
- A *targeted tax credit with accompanying measures*, which restricts the previous tax credit to the 80% lower-income households, devotes the remaining tax proceeds to payroll tax reductions, and finances, on the remaining budget margin,[31] additional measures for the households that combine poverty and dependence on fossil fuels.[32] These measures include the accelerated provision of energy efficient equipments (building, heating, household appliances) or discounts on the price of public transport. They aim at reducing 'energy poverty traps', i.e. at facilitating the transition of 'captive' consumers to a low-carbon economy.

[29] The VAT compounded on the carbon taxis also redistributed.

[30] The percentage is computed to cover the average annual daily commute to work of French households.

[31] Under the maintained constraint of constant public debt to GDP ratio.

[32] Modelled as a transfer decreasing with income and limited to the 80% lower-income households. The impacts on energy efficiency are not considered.



Variations of the consumption of the bottom twentile and GDP are in real terms. The inverted Gini index is computed on consumption rather than income.

Figure 5 Three reforms offering a compromise between the equity and efficiency criteria

Two of these three compromises perform better than the historical situation on the four synthetic dimensions previously retained (Figure 5). The option of a generalised tax credit performs significantly worse than the other two in terms of equity (consumption of the bottom twentile and notably the inverted Gini index). This is however not justified by a greatly improved performance in employment and activity, particularly relative to the targeted tax credit with accompanying measures.

The latter option and the mixed recycling one have comparable performances, although the mixed recycling exhibits indicators that are systematically slightly inferior.

The economic cost of a system of direct compensation ultimately varies in proportion to the resource dedicated to its funding (Table 7). The larger this resource, the lower the transfer of the fiscal burden from domestic production to non-wage income, and hence the lower the decrease in the production cost. In this light it is no wonder that the mixed recycling has a higher cost than the targeted tax credit & measures option: it consumes 37.5% of the tax proceeds that are no longer available for reductions in payroll taxes; the virtuous circle of growth and employment is therefore weakened and room for manoeuvre is reduced. At a lower financing cost (26.5% of the proceeds), the targeted tax credit & measures option restricts the compensation to more vulnerable households for a higher equity impact. It also favours the middle class, who is more vulnerable to the carbon tax in the other two options (its share of households' disposable income is now rising by 0.1 points).[33]

Direct compensation scheme		Generalised tax credit	Mixed recycling	Targeted tax credit and measures
Share of tax proceeds funding compensation		17.8%	37.5%	26.5%
Producer price of the composite good		-0.2%	+0.8%	+0.3%
Share of household disposable income (% points)	Poor (F0-5)	+0.0	+0.1	+0.1
	Lower class (F5-35)	+0.1	+0.3	+0.5
	Middle class (F35-65)	-0.1	-0.0	+0.1
	Upper class (F65-95)	-0.2	-0.4	-0.6
	Rich (F95-100)	+0.1	+0.0	-0.0

F#-#: income classes (F0-5: the 5% poorest, *etc.*)

Table 7 Impacts on the price and income distribution of 3 direct compensation schemes for a €300/tCO_2 carbon tax

Finally, our simulations do not account for the additional advantage of the targeted tax credit & measures of further concentrating on situations of energy vulnerability that are not strictly correlated to income levels (location, climate, *etc.*). In this regard a balance must be found between the benefits of a more equitable distribution of the tax burden and the administrative costs of more complex allocation rules.

Conclusion

This article confirms that the link between a carbon tax, income distribution and the situation of the lower-income households is highly sensitive to the use made of the carbon tax proceeds. A second, less trivial conclusion is that there is no absolute independence in a second best world between compensation for the immediate and unequal effects of a carbon tax and its overall economic performance (income and employment). Thus a full and equal redistribution to households, subject to a constant public debt to GDP ratio, reduces poverty and inequality, but at the cost of a contraction in investment, competitiveness and growth.

[33] The general vulnerability of the middle class to the tax is notable. It is caused by a budget share comparable to that of the bottom twentile, but a much smaller benefit from employment gains.

The critical point of a carbon tax reform in any open economy is ultimately to contain the impact of higher energy costs on production costs, which affects the purchasing power of households and the international competitiveness of firms.[34] This explains the dominance of any option involving lower labour costs for the production system. The firsthand unequal impact of a carbon tax is not thereby reduced, but room for manoeuvre is gained to reconcile equity, employment and activity.

Because the tax proceeds diverted from lowering payroll taxes must be minimised, the better solution is to proceed to the compensation of the tax incurred on basic energy needs, and to adopt complementary measures targeting the situations of energy vulnerability (that are far from being systematically correlated to low levels of income). Another option is a mixed recycling where only funds collected from firms are used to lower payroll taxes. But this option does not allow for the transfer on the non-wage income of a part of the tax burden that falls on the production system.

The analysis was conducted assuming a general tax without incorporating the specific situation of energy intensive industries exposed to international competition. This would require tackling the complex discussion of EU-ETS and issues of international competitiveness of these industries (Hourcade *et al*. 2007) that are beyond the scope of this article.[35]

In terms of economic policy, our findings suggest that the introduction of a carbon tax should be associated with an overall negotiation. This would include topics as diverse as the regulation of labour markets in a strong international economic competition, financing of pensions or healthcare, or energy efficiency programs for the most vulnerable households.

From this point of view, we emphasise that promoting low energy prices proves over time to be an unequal policy. Waiting for alternative solutions to fossil fuels to raise a carbon tax is forgetting that their penetration will be slowed down by low energy prices. This would also lead to trap vulnerable households in locations, housing environments and types of equipment that make them highly exposed to unavoidable oil prices hikes—an energy security dimension that we cannot forget.

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[34] This explains why recycling schemes that do not limit the increase of production costs are conditioned to border tax adjustments, as advocated by Schubert (2009) in the French context. The diplomatic consequences of such adjustments, in a context where the priority of international climate policy is the inclusion of emerging countries in a global negotiation process, cannot be ignored.

[35] On the specific question of the possible links between the carbon tax and the EU-ETS *cf.* Godard (2010).

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