

The equity and efficiency trade-off of carbon tax revenue recycling : A reexamination

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Abstract

This paper examines the macroeconomic and distributive impacts of a carbon pricing reform. We propose a comprehensive analytical framework encompassing modern macroeconomics, public economics of taxation and energy and environmental economics. We analyse an alternative widely debated for the use of carbon tax revenues: lump sum transfers vs. cuts in existing distortionary taxes. We provide new insights on the efficiency vs. equity trade-offs of carbon pricing policies in the context of an open economy with the case study of France. We show that the terms of the equity-efficiency dilemma and the hierarchy of the revenue recycling options crucially depend on the macroeconomic context and on the type of inequalities considered. We show that it is paramount to identify the most vulnerable households and to define the criteria used to award lump-sum transfers accordingly. We conclude that no revenue recycling option is universally superior to another, and more case studies should be carried out to account for specific macroeconomic and national contexts.

Keywords: Carbon tax revenue recycling; Equity; Efficiency; Hybrid recycling

JEL Classification: Q01 ; Q5.

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1 Introduction

At the Paris climate conference in December 2015, 195 countries collectively committed for the first time to limit the increase in global average temperature to well below 2°C above pre-industrial levels. The Paris Agreement also brought a new momentum to put a price on carbon. Indeed, nearly half of the national pledges submitted before the Paris climate conference refer to carbon pricing (The World Bank, 2016), and many countries have already implemented carbon pricing in the form of tradable emission permits or carbon taxation¹. Carbon pricing has been consistently prescribed as an efficient way to mitigate climate change since at least (Pearce, 1991). However, it has faced oppositions based on two major arguments: that of competitiveness distortion, and that of a negative impact on the poorest households (Ekins, 1999). Indeed, the social impact of carbon pricing could be regressive if the cost is borne disproportionately by the most vulnerable or whether the richest households receive a disproportionate share of its economic benefits. Ultimately, the social impact of carbon pricing is linked to the use made of the proceeds, and the implementation of carbon pricing policies is often hindered by disagreements about how to best use the associated revenues.

Historically, economists have argued in favour of recycling carbon tax revenues to finance a reduction in distortionary taxes (such as income or sales taxes) as opposed to redistributing the revenues directly to household through lump-sum transfers. This is because cutting distortionary taxes may be superior in terms of allocative efficiency (employment, private income and welfare) and may thus also improve the economic situation of some vulnerable groups. Lump-sum transfers, however, provide a direct and guaranteed compensation to specific vulnerable groups, for instance those whose energy bills are a very large share of their income. The issue of the best recycling strategy relates to a challenging problem of public economics, namely how to design an environmental policy that is both efficient and equitable². This issue has been the topic of a large and still growing body of literature³, which we review in section 2. In a

¹They include the European Union (with the EU ETS and national carbon taxes in many EU countries), Japan and South Africa.

²This body of literature takes roots in the seminal work of Mirrlees (1971), and was applied to externality-correcting taxes by Sandmo (1975). They consider that tax instruments and targets interact, and therefore, cannot be optimised separately.

³Lipsey and Lancaster (1956) first stated that distortions occurring anywhere in the economy may disrupt the standard conditions for optimality (in our case, the first-best optimal solution is to set the environmental tax at its Pigouvian level and to restore equity with non-distortionary lump-sum transfers by organizing cash transfers from the winners to the losers). In the real world, however, there are distortions imposed by other taxes, other market failures, or government failures. Consequently, there is no general answer. As emphasized by Drèze and Stern (1987): “In particular situations there is no alternative to identifying carefully the functioning of the economy, the planner’s objectives, his instruments and the constraints circumscribing their use, and then

nutshell, the optimal policy greatly depends on (i) the set of ethical judgements used to define the objective function of the social planner (e.g. environmental quality, public good provision, private consumption, inequality reduction), and (ii) the economic model used to explore the effects of alternative policies on the objective function (e.g. functioning of markets, income distribution, availability of public information). Models that describe imperfect markets and asymmetric information are needed to represent the equity-efficiency dilemma in a meaningful and realistic way.

As models have come to encompass a wider variety of normative and positive assumptions, the consensus on the best revenue-recycling strategy has actually weakened. In this paper, we propose a way forward that acknowledges the lack of consensus on these issues, and clearly separates the positive features of the economic model and the normative evaluation of policies. We take two major steps: (1) we recognize that no social objective function pre-exists the analysis as the set of objectives used by society cannot be known ex-ante, and (2) we consider macroeconomic behaviours that can be far distant from the well theoretically-founded model of a perfect market economy. The idea here is not to design and use a model that would allow us to optimise a given welfare function and conclude on one optimal policy: this would be an impossible task considering the two previous propositions. Instead, we aim at disentangling the influence of normative parameters (i.e. ethical values) and positive parameters (i.e. parameters that govern the functioning of the economy) in the policy evaluation. This is done as follows.

- We perform a multi-criteria analysis where we focus on the equity-efficiency trade-off. We consider two criteria for each dimension (i.e. two distributive indicators and two aggregate indicators). We discuss the choice of these indicators, as well as the importance of considering non-income dimensions of inequalities (horizontal equity). This approach is justified by considering that the ethical judgements used by society to design a tax reform will only be revealed as the democratic debate unfolds. We assume a process of decentralised decision and collective bargaining⁴ in which stakeholders may agree on a range of evaluation criteria.

deriving the appropriate shadow pricing formulae” (p. 953).

⁴We assume that the evaluation is performed before the process of collective bargaining takes place. The set of objectives pursued by the society will emerge from that process of collective bargaining. Therefore, there is no social objective function available to compare the different reform schemes. An alternative option would be to reveal the social objective parameters by considering that the actual tax system is optimal from a non-environmental point of view (Ahmad and Stern, 1984). However, we consider that social preferences are not stable and the stakeholders’ judgements about the desirability of a given state evolve with the policy context and the democratic debate.

- We consider a model that allows for sensitivity tests on a range of parameters that govern the functioning of the economic system. These parameters influence the performance of policies in terms of equity and efficiency. More precisely, we model an open economy in general equilibrium, in which involuntary unemployment can arise from non-clearing wages and shortage of effective demand. This economy exhibits a high dependence on fossil energy, resulting from past investments made under imperfect expectations about future energy constraints. As a consequence, fossil energy consumption is initially high and the level of employment is low. In this context, the tax system has a distortionary effect on employment through the demand side. Therefore, using carbon tax revenues to reduce distortionary taxes can be an attractive option. The distribution of income among firms, government, foreigners and various income groups may not be initially equitable. Even if a higher level of employment benefits the worst off, there is no guarantee that those benefits will offset the costs of higher energy bills. Similarly, even if the situation of the worst off actually improves, there is no guarantee that inequalities will be reduced. In that setting, uniform or progressive lump-sum redistribution can be attractive, as it allows for more redistribution and direct compensations.

Under these assumptions, we find that a hybrid revenue-recycling scheme is desirable. In this hybrid scheme, a portion of the tax revenue is dedicated to lump-sum transfers, while the remaining is used to reduce other existing taxes that weigh on production costs. Accounting for the fact that tax authorities may lack sufficient information to identify the most vulnerable households, we examine various ways of implementing such a hybrid strategy. We also analyse the sensitivity of the results to the reaction of net wages, the response of international trade, and the equity criterion (poverty and horizontal and vertical inequalities).

The paper is structured as follows. Section 2 presents the literature review. Section 3 describes the analytical framework. Section 4 examines the performance of various revenue-recycling options: we first compare a uniform cut in labour taxes to uniform lump-sum transfers, then examine hybrid options. Section 5 provides a sensitivity analysis of the results to positive and normative parameters. Section 6 concludes.

2 Literature review

When assuming perfect markets and a perfect information economy (i.e. when using the Arrow-Debreu Walrasian model), according to the second welfare theorem, public administrations can always finance public goods and redistribute wealth by using non-distortionary lump-sum transfers. Consequently, an environmental tax is set to match environmental considerations only (Pigou, 1932), and equity is restored by organizing transfers from the winners to the losers (Kaldor-Hicks principle). The issue of the best revenue recycling scheme arises when one acknowledges market imperfections and the limitations of public information. Following Mirrlees (1971), modern theories of taxation assume that fiscal administrations cannot apply non-distortionary lump-sum transfers because the implementation of such individualised transfers requires full information on individual situations. If public authorities do not use lump-sum transfers, they have to set the other tax instruments in a way that balances the goals of environmental protection, public good provision, private welfare and distributional equity (Sandmo, 1975). In that case, introducing a new environmental tax component provides additional public revenue that can be recycled to finance reductions in other distortive taxes. Two main strands of modern literature have contributed to identify the most harmful taxes and thus the best recycling options: the double dividend literature and the modern optimal taxation literature.

The double dividend literature has explored various sources of tax distortions measured with the standard criterion of economic efficiency⁵, for a review see Goulder (1995, 2013) and (Bovenberg, 1999). A prominent source of tax distortion is the disincentive effects of taxes on employment. This literature has shown that a carbon tax, by increasing production costs and the living costs of consumers, contributes to increase pre-existing tax distortions on labour supply or labour demand. As a consequence, the best recycling scheme is not to redistribute revenues through lump-sum transfers (even when non-distortionary transfers are possible), but to reduce other pre-existing taxes that distort employment choices (i.e. labour or capital taxes). The difficulty comes from the fact that this disincentive effect itself depends on the assumed functioning of the labour market, which is uncertain. Assuming a competitive labour market, early analyses have found that increasing energy taxes is somewhat equivalent to increasing labour taxes (Bovenberg and de Mooij, 1994): increasing energy taxes raises living costs and incites consumers to reduce their labour supply, just as increasing labour taxes does by reducing after-tax wage income.

⁵That is deviation from a Pareto optimal allocation of resources. A system of lump-sum taxes can be optimal from this point of view if it is design such that it is neutral with respect to all marginal evaluations made by consumers and producers. This requires that fiscal administrations knows all these marginal evaluations.

Therefore, in a competitive model of the labour market, employment can increase if labour supply is less sensitive to energy taxes than it is to labour taxes. In all types of models, employment may increase if two conditions are met: 1) the tax burden shifts towards some types of income without reducing employment and 2) this is actually the case when labour taxes are substituted for energy taxes. Most of the subsequent literature has focused on non-labour income (social transfers, pure profits or rents from fixed factors of production) and has introduced realistic non-competitive features of the labour market. Both assumptions, together, allow for better outcomes in terms of employment. For instance, [Koskela and Schöb \(1999\)](#) show how the reform can shift the tax burden from workers to the unemployed without reducing employment. The authors assume that the unemployed are not subject to labour taxes and their unemployment benefits do not increase when they pay higher energy taxes. In their bargaining model of the labour market, lower real unemployment benefits reduce the ‘outside options’ of workers, who accept lower real wages. Hence employment increases with labour demand. In summary, the literature shows that the relative superiority of labour tax reductions over lump-sum transfers greatly depends on the functioning of the labour market, the response of wages and the sources of unemployment.

Following a long-standing tradition in welfare economics, most of this literature has assumed a representative consumer and has mostly neglected population heterogeneity. It remains that the kind of mechanisms described above supposes that the tax burden is shifted from some individuals to others. But the models used usually include functional distributions (between production factors: wages, profits, rents, etc.), and not personal inequalities (between individuals with different levels of income). A more comprehensive evaluation should thus account for the implied inter-personal redistribution. On this matter, the previous strand of literature does not provide clear-cut conclusions. On the one hand, [Bovenberg \(1999\)](#) argues that a uniform reduction of distortionary taxes may increase employment but with undesirable consequences in terms of redistribution (unfair to those who suffer disproportionately more from higher energy prices and do not benefit from higher employment or income, e.g. the unemployed in Koskela and Schöb). On the other hand, the reform may also benefit the poorest households as the wealthiest consume more energy and the poor suffer more from high unemployment. In fact, when considering the performance of a revenue recycling scheme in terms of both employment and distributional equity, uniformly cutting distortionary pre-existing taxes may not be the optimal policy in all cases.

This result has been underlined by a second strand of literature: modern theoretical optimal taxation. Using Mirrlees-type models that account for inter-personal inequalities, this literature has long discussed how to balance equity and efficiency objectives in a set of optimal tax rates. When no lump-sum transfers are available, the optimal energy tax rate must balance the environmental goal of mitigating CO_2 emissions with minimizing the deadweight loss of taxation and optimizing the redistribution (Cremer et al., 1998). This can lead to substantial reductions in the tax rate compared to the Pigouvian rate if the energy tax weighs more on the poor (Cremer et al., 2003). However, when uniform lump-sum transfers are available, reconciling equity and efficiency objectives may be attained optimally through higher uniform lump-sum transfers rather than tax cuts (Jacobs and de Mooij, 2015).

3 Analytical framework

Models which account for imperfect markets and asymmetric information can reveal the conflicts that may exist between equity and efficiency. In order to account for both equity and efficiency dimensions in the policy evaluation, we do not optimize a social welfare function. Instead, we propose a multi-criteria analysis, which clearly separates positive and normative dimensions. For a given policy, the trade-off between equity and efficiency goals is mapped on a single snapshot.

3.1 Brief model description

In this study, we use the IMACLIM-S model of the French economy. IMACLIM-S France (Gherzi and Hourcade, 2006), (Gherzi et al., 2009) is a computable general equilibrium model that describes an open-economy. Following Samuelson (1947), the model uses comparative statics⁶, and distorts the ‘image’ of a no-policy economy hit by an external shock: the carbon tax. The model is not used as an optimisation tool to determine the optimal policy from a cost-effectiveness point of view. Instead, the model evaluates the impact of an exogenous carbon tax, which may lead to different emissions depending on assumptions on the functioning of the economy. The model distinguishes three types of agents and the rest of the world. Households are disaggregated into twenty living standard classes. The model describes four types of production, namely crude oil, automotive fuels, other energy goods for housing and

⁶IMACLIM also exists in a dynamic, recursive version IMACLIM-R (Waisman et al., 2012).

a composite good aggregating all non-energy goods and services⁷. It is a hybrid model in the sense that it describes energy volumes that result from an effort to harmonise national accounts statistics with energy balances and energy prices statistics in the reference year. This so-called hybridisation of the input-output table allows including engineering expertise about technical flexibility at a given time horizon. In particular, energy efficiency improvements of equipment and infrastructures used for production and end-use are bounded by exogenous asymptotes⁸. As a result, the model exhibits price elasticities that gradually decrease as relative energy prices increase (instead of constant price elasticities, which are more commonly used).

3.2 Model mechanisms

We offer a general overview of the mechanisms at play in our model, which will be particularly relevant to the interpretation of the results presented in section 4. Consider an open economy which produces an aggregate product of non-energy goods and services using energy, non-energy inputs, fixed capital and labour. Energy is produced, transformed and traded with other countries. The population is composed of heterogeneous households who consume energy for private transportation and residential services. National production is partly purchased by domestic agents and partly exported. We assume the prevalence of Keynesian unemployment, in the sense that there is excess supply of labour (involuntary unemployment) and shortage of demand in the products market (excess productive capacities). We assume that any gap between domestic energy demand and supply is filled by unrestricted energy imports. Overall, the actual level of employment is constrained by the level of aggregate demand (Y) of products.

3.2.1 Aggregate demand, employment, and the effect of international competition

a) Aggregate demand

Aggregate demand (Y) depends both on internal demand (C) and external trade (exports X minus imports M). Internal demand depends on the real purchasing power of domestic agents after the payment of their final energy bills. Internal demand decreases with final energy needs

⁷The energy mix heterogeneity of automotive fuels and the aggregate of residential energy is accounted for through agent-specific prices and CO_2 contents.

⁸This 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.

(C_E), energy prices (p_E), and the prices of domestic products (p) and imported products (p^*). It increases with the available income devoted to current expenditures (ϕ). The trade balance depends to some extent on the domestic costs of production. It tends to improve with the real exchange rate (p^*/p). Under the assumptions of a small country, p^* is constant, and aggregate demand takes the following form:

$$Y = C[CE, p_E, p, \phi[w, p, Y, \alpha]] + (X - M)[p] \quad (1)$$

with the partial derivatives, $C'CE < 0$, $C'p_E < 0$, $C'p < 0$, $C'\phi > 0$, $(X - M)'p < p$

Let us now consider the effect of a carbon tax combined with a revenue recycling scheme. A higher energy price (p_E) has a direct depressive effect on internal demand if the final energy consumption (CE) is not very elastic to prices and if there is no additional income to fuel the expenditure budget (ϕ). Thus, a lump-sum redistribution of tax proceeds would compensate this depressive effect. In particular, if the richest fragments of the population consume more energy in absolute terms, a uniform redistribution of the tax will benefit the poorest fragments. If the latter devote a larger share of their income to current expenditures, internal demand may increase. However, for matters of incentive efficiency, the energy taxation has to be broad-based (exemptions and loopholes must be avoided as much as possible). Hence, the tax will also increase the costs of production (as domestic producers use energy to produce Y), hence increase domestic production prices (p). It is thus possible that the direct lump-sum compensation of households would not be sufficient to offset the depressive effect of higher domestic production prices on the trade balance ($X - M$) and on internal demand (C).

The effect of a carbon tax on the level of domestic production prices is governed by the set of assumptions that determine the level of non-clearing prices. Altogether, these assumptions determine the level of aggregate supply that is profitable for producers at any price level (p). The price (p) is set by a margin over the marginal cost (MC), with the mark-up (μ) depending on various factors related to the competitive conditions in the products markets and the accessibility of funds in financial markets⁹. Thus, the price-setting function (the pricing rule) takes

⁹Assumptions concerning the dependence of this aggregate mark-up with the endogenous variables of the model will play a role on the result. How this mark-up will evolve is a debated question. To keep our discussion in its simplest form, we assume a fixed mark-up, which only captures the existence of a possible gap between actual market prices and marginal costs. On the income side, it also captures in an abstracted way the existence of some level of financial and real estate rents in the economy. Of course, at the extreme (when $\mu = 1$), we get the case of pure competitive markets. The marginal cost of production increases with the factor prices (p_E for energy, p for other fixed and variable inputs, p_L for labour) and with the marginal consumption of inputs to produce one unit of product (respectively e , ci , l , for energy, other inputs and labour).

the following form:

$$p = \mu \cdot MC[p_E, p, p_L, e, ci, l] \quad (2)$$

with the partial derivatives, $MC'_{p_E} > 0$, $MC'_p > 0$, $MC'_{p_L} > 0$, $MC'_e > 0$, $MC'_{ci} > 0$, $MC'_l > 0$

The carbon tax increases production costs if the profit margins are fixed and if the economy cannot substitute away from fossil energy and thus cannot produce the same level (Y) of non-energy goods and services without additional costs. In this case, the carbon tax induces a general price inflation which reduces aggregate demand. Therefore, reducing the labour tax may contribute to mitigate this effect on production costs by lowering labour costs (p_L). Labour intensive industries would benefit from this tax shift while carbon intensive industries will not, but, as a whole, labour costs being widely distributed among industries, the general cost increase due to the carbon tax will be mitigated compared to the alternative lump-sum redistribution strategy. Furthermore, if the labour tax was substituted for all additional tax revenue (that is, including the revenue raised on final energy consumption C_E), production costs may even be reduced, compared to their initial levels. This would improve the trade balance. However, the overall effect of reducing labour taxes on internal demand (C) is unclear. On the one hand, domestic agents would face higher energy bills that are not compensated by direct lump-sum transfers. On the other hand, they would face lower non-energy prices, and employment and income would increase thanks to the improved trade balance. Both effects will not be equally distributed in the population, and it is not clear how the overall redistribution will affect the aggregate expenditure budget¹⁰, ϕ .

b) Employment and wages

Let us now consider the effect of revenue recycling schemes on employment and wages. In the literature, the employment effect of the tax shift described above is shown to be very sensitive to the way wages are modelled. Here, we consider that net wages endogenously respond to some variables, but in a way that does not necessarily clear the labour market¹¹. For our analysis, it is sufficient to assume that wages respond negatively to the level of unemployment (as tensions

¹⁰Note that we have so far implicitly assumed fixed net-of-tax wages.

¹¹In the modern labour market literature, many microeconomic foundations justify deviations from the theoretical reference of market-clearing wages, as the real macroeconomic behaviour of wages results from a complex aggregation of heterogeneous microeconomic situations. Wages also respond to institutional arrangement and social norms that evolve through time.

in the labour market decrease) and positively to the level of consumer prices (as workers wish to index their income on the cost of living). With a given active population, the level of unemployment decreases with production (Y) and with its labour intensity (l). The consumer price index (CPI) increases with the prices of energy (p_E) and with the price of non-energy products (p and p^*), according to the structure of the consumption basket (C_E, C, M). According to consumer theory, this structure evolves with relative prices and with the expenditure budget (ϕ). The adjustment of the structure of the consumption basket mitigates the effect of higher product prices, since consumers tend to re-allocate their consumption budget towards cheaper consumption goods. However, under the assumption of limited reactions to prices and limited substitution possibilities, the direct price effect on the CPI can dominate. The evolution of the structure of the consumption basket and of the CPI with the expenditure budget (ϕ) is not straightforward, neither is the evolution of its distribution among the (heterogeneous) population. Here, we assume that for a given set of prices, the share of energy expenditures decreases with the budget¹² ϕ , because final energy services include some basic needs. As a whole, the wage setting function takes the following form:

$$\frac{w}{CPI[p_E, p, \phi]^\gamma} = u[Y, l]^{-\lambda} \quad (3)$$

with the partial derivatives, $CPI'_{p_E} > 0$, $CPI'_p > 0$, $u'Y < 0$, $u'l < 0$

Parameters $\lambda \in [0; 1]$ and $\gamma \in [0; +\infty[$ give the degrees of real and nominal wage rigidities, respectively. Combining the wage-setting function with the price-setting function gives the supply curve, where labour costs (p_L) is a function of the labour tax (t_L) and of the net nominal wage (w).

$$\begin{aligned} p &= \mu \cdot MC[p_E, p, p_L[t_L, w], e, ci, l] \\ &= \mu \cdot MC[p_E, p, p_L[t_L, w[p_E, p, \phi, Y, l]], e, ci, l] \end{aligned} \quad (4)$$

with the partial derivatives, $MC'_{p_E} > 0$, $MC'_p > 0$, $MC'_{t_L} > 0$, $MC'_Y > 0$, $MC'_e > 0$, $MC'_{ci} > 0$, $MC'_l > 0$

When taking into account the response of wages, the ultimate effect of recycling tax revenues

¹²At least in the case of a uniform increase of budget in the population. This cannot be the case, however, in the case of higher inequalities, for instance if the budget increase is concentrated towards the higher fragments of the population, while the lower fragments experience contractions of their budget instead.

towards tax cuts on production prices is unclear, as the positive effect of lower labour taxes on labour costs may be offset by higher after-tax wages. Indeed, low substitution possibilities in the demand side may lead to a higher consumer price index (*CPI*) and may thus put upward pressure on wages. More precisely, under low nominal rigidities (γ close to 1), workers may actually succeed in getting higher after-tax wages, which can limit or even cancel out the cost reduction from lower labour taxes¹³. The effect of lump-sum recycling is more straightforward: lump-sum compensation feeds the budget (ϕ) and allows maintaining the level of wages, even when nominal rigidities do not exist. Thus, production prices tend to increase, as higher energy costs are not compensated by lower labour costs.

c) International competition

To summarize, both revenue recycling options feed demand, although via different channels. The labour tax reduction, by moderating prices, primarily benefits external demand. The lump-sum compensation, by feeding the budget (ϕ), sustains internal demand¹⁴. The revenue recycling options have different effects on production costs and demand. What is their net general equilibrium effect? The equilibrium solution appears at the crossing of the aggregate supply curve (4) and the aggregate demand curve (1). In an economy where domestic producers are little exposed to international price competition (low derivative $(X - M)'p$ of the real trade balance to the real exchange rate), both recycling options have rather similar consequences on aggregate demand. Indeed, reducing labour taxes leads to lower production prices (according to the degree of wage rigidities, see 4), but lower domestic prices have no significant positive effect on external demand. As a consequence, the difference between tax cuts and lump-sum redistribution is narrow, as this last option preserves internal demand (by increasing the budget). However, the effects of both recycling options on aggregate demand and employment are more contrasted in the case of fierce international price competition (low **high** derivative $(X - M)'p$). In that case, lower production prices due to labour tax cuts lead to higher external demand, which generates additional income, and therefore increases the budget available for internal consumption (ϕ). From equation 1, one can show that the equilibrium level of production (Y) needs to be higher than the initial increase in trade $d(X - M)$. A multiplier effect takes

¹³However, in a context of sluggish demand, inexistent inflation, and sharp international competition, the bargaining power of workers may not be that strong. Note that under nominal rigidities (γ close to 0), a rise of energy prices will not necessarily translate into higher wages.

¹⁴In particular if the redistribution is progressive towards the lower income groups who consume a larger share of their income.

place. The inverse mechanism is at play when tax revenues are redistributed through lump-sum transfers. In that case, domestic prices are higher, the trade balance deteriorates, and the income available for domestic products is reduced.

3.2.2 Population heterogeneity and income distribution

The redistributive consequences of alternative revenue recycling schemes depend on the way the heterogeneity of the population is modelled. The redistributive effect of revenue recycling schemes result from the heterogeneity of: (i) 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 consumption¹⁵; (ii) the sensitivity of income structures to variations of wages and the interest rate, given that per capita social transfers are indexed on net wages; (iii) 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. In the model, income is distributed among three main types of domestic agents (households, a representative firm, and a public administration) and the rest of the world. The value added from production is divided into labour and production taxes, labour income and capital income. The way labour income (I_L) is distributed among household groups depends on the wage differentials (w_h) and the distribution of jobs (L_h). Redistribution of capital income (I_K) occurs through the payment of interests and dividends in financial markets. These payments are made according to the net financial position of agents, which evolves with the interest rate and the amounts lent or borrowed (difference between income I_h and expenditures E_h). Redistribution also occurs through direct transfers among domestic agents and with foreigners ($V_{i,h}$), and also through the tax and benefit system. Each household group pays a differentiated income tax (T_h) and receives social transfers ($B_{i,h}$). These transfers increase with unemployment benefits (which increase with employment L_h), and evolve with the consumer price index (CPI) and wages (w) according to the indexation rules of the per capita benefits. The disposable income (I_h) available to each group is then defined as follows:

$$I_h = (1 - T_h) \cdot (I_L, h[w_h, L_h] + I_{K,h}[I_h - E_h] + V_{i,h} + B_{i,h}[L_h, CPI, w]) \quad (5)$$

¹⁵Asymptotes 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.

Income is redistributed indirectly through the effect of the reform on aggregate employment, after-tax wages and profits according to the general equilibrium mechanisms sketched above. In the case of lump-sum redistribution, uniform or progressive transfers also add to already existing social transfers ($B_{i,h}$). The scale of the effect of the reform is subject to large uncertainties, and crucially depends on assumptions on substitution possibilities in production, on the distribution of wages and jobs, and on the indexation rules of social benefits. In what follows, we assume homothetic variations in wages (wage inequalities between groups are constant) and constant direct transfers ($V_{i,h}$) in percentage of GDP. Capital income evolves endogenously, but its distribution is largely determined by the initial situation (which is in favour of the highest income groups in our case study). Social transfers are indexed on wages and concentrated in the bottom income groups. We also assume homothetic variations of jobs (groups with higher initial unemployment experience higher job variations??). As a consequence, changes in unemployment (L_h) affect the poorest groups of the population more.

Each household group uses a proportion (c) of its income to consume energy and non-energy products ($C_{E,h}$, C_h). Each household class also invests a proportion (g) of its income in capital formation. The difference between income (I_h) and expenditures (E_h) (consumption and investment) is borrowed or loaned on financial markets.

$$I_h - E_h = (1 - c_h - g_h) \cdot I_h \quad (6)$$

The evolution of net financial positions only modifies the redistribution of capital income. Therefore, the remaining purchasing power is simply given by the following expression:

$$C_h = 1/p \cdot (\phi[I_h, c_h] - p_E \cdot C_E) \quad (7)$$

with $\phi[I_h, c_h] = c_h \cdot I_h$

The distributional effect in terms of non-energy consumption depends on the distribution of disposable income (I_h), the proportion of income consumed (c), and the energy bill $p_E \cdot C$. The capacity of household groups to reduce their energy consumption C_E in response to higher energy prices depends on their substitution possibilities and energy needs. The information on this matter is very limited, as household groups combine very heterogeneous situations in terms of geographical locations, heating, cooking and electric equipment, private vehicle ownership, and other socio-demographic variables that together determine the energy dependence of households.

In what follows, we assume that substitution possibilities are limited by an incompressible level of basic energy needs E^* . In the absence of accurate information on substitution possibilities, we also consider identical price elasticities and income-elasticities for fossil energy consumption among income groups. In this framework however, lower income groups have a larger share of their budget devoted to energy consumption, and their energy consumption is closer to the basic level of energy needs E^* . As a consequence, higher energy prices tend to increase consumption inequalities. However, the net distributional outcome depends on the recycling strategy and on the overall income redistribution.

3.3 Data and numerical experiment

3.3.1 Data

The model is calibrated on 2004 French data (INSEE, 2004), (IEA, 2007). Its formal structure, reference tables and parameter values are available online [where?](#). The no-tax scenario is calibrated on 2004 France, which is modelled as an economy with 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 variations¹⁶.

The French 2001 Budget des Familles (hereafter BDF) survey covers a cross-section of 10305 households (INSEE, 2001). Starting from this data, distributional effects are analysed on twenty income classes, characterised by specific structures of income and expenditure, savings rates and direct tax rates, and net financial positions. Households in the top living standard twentile¹⁷ 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% lower¹⁸. Therefore, although higher income households consume more energy and are bound to pay more carbon tax in absolute terms, the fact that

¹⁶The 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).

¹⁷Here 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 child 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).

¹⁸The ratio is confirmed by the ADEME for 2006 (ADEME, 2008).

the budget share of energy is larger for the lower income households means that the direct impact of a carbon tax on the welfare of households is regressive. The energy budget shares vary substantially within each twentile. Indeed, multiple factors beyond sheer living standard determine these shares and thus vulnerability to energy prices (local climate, local density, availability of public transport, 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 motorized than the bottom twentile (80% vs. 65%).

3.4 Outline of the numerical experiment

We perform a numerical experiment to assess the performance of contrasting revenue recycling policies according to several criteria and assuming various characteristics of the functioning of the economy. We assess the performance of five revenue recycling options: two polar and three hybrid cases. In the two polar cases, revenues are either recycled towards labour tax cuts or through lump-sum transfers to households (section 4.1), and the hybrid cases combine lower labour taxes and lump-sum transfers to households to various degrees (section 4.2). In order to assess the equity-efficiency trade-off of the reforms, we consider two efficiency and two equity criteria. The two efficiency criteria are the aggregate levels of employment and real GDP (computed with the Fisher quantity index). The two equity criteria are the level of non-energy consumption of the poorest group of households (indicator of poverty) and the Gini inequality index for the consumption of non-energy goods across household groups (indicator of inequality)¹⁹. Although a multi-criteria analysis does not allow identifying the optimal policy, it provides insights on the best reforms, i.e. those which improve most criteria. This methodology clearly separates the influence of positive parameters associated with the functioning of the economy (wage behaviour, external trade, etc.) from the influence of normative parameters (inequality aversion, level of employment, GDP, etc.) on the preferred policy option. Define what we mean by efficiency (not in terms of welfare here).

¹⁹Note that we have not specified a particular form of private welfare function. We have only assumed that the energy consumption of each household group tend to decrease with the relative price of energy and to increase with the consumption budget according to some price and income elasticities, and under the constraint that some basic level of energy consumption is satisfied. We do not assume any representative behaviour for the various income groups, therefore we do not use variation of private welfare for the evaluation. It remains that the level of non-energy consumption is a criterion that does not include the private utility derived from energy consumption and services. This must be kept in mind, and we will complement this indicator by measures of income inequalities.

The model allows testing for contrasted assumptions on the functioning of the economy with regard to the terms of trade and the operation of the labour market. In the central case, we assume an elasticity of nominal wages to the unemployment rate of -0.1. We consider nominal wages to reflect the idea that workers may not be able to negotiate higher wages in an open economy, especially in the context of an economic crisis. While this scenario is seldom considered in the double dividend literature, we find it an interesting case study. We use the same value of elasticity as [Blanchflower and Oswald \(2005\)](#), although the authors used this value for the elasticity of real wages to the unemployment rate. Imports and exports are assumed to respond to domestic and international prices, with a domestic price elasticity of exports of -0.06 (same as in the MESANGE model of the French economy (REF?)), and a domestic price elasticity of imports of 0.01 (REF?).

There are wide uncertainties on macroeconomic conditions, and we do not claim that these parameter values perfectly reflect the functioning of the French economy. The aim here is not to identify one optimal policy. Instead, we use the above defined central case to illustrate the mechanisms at play (sections 4.1 and 4.2), and then test for the sensitivity of the results to these assumptions (section 4.3), in order to identify key uncertain parameters to be further examined (and debated) when choosing between revenue recycling options. We show that these assumptions impact the order of merit of revenue recycling options.

Finding a suitable revenue recycling scheme boils down to striking a balance between mitigating the rise of production costs due to the carbon tax and maintaining a sufficient level of wages, while targeting the most vulnerable households for wealth redistribution. This balance translates into the share of revenues to be allocated to lump-sum transfers while the rest is used to reduce labour taxes. The appropriate share depends on the characteristics of the economy (particularly the level of economic openness, which depends on the country considered).

4 Results

4.1 Revenue recycling schemes: two polar cases

We first examine the impact of recycling carbon tax revenues to cut labour taxes under the constraint of a constant public debt to GDP ratio (i.e. in a neutral way as regards public budgets and intergenerational equity), and then compare this revenue recycling scheme to lump-sum transfers, where all tax proceeds, including those levied on firms, are rebated to households

in even shares²⁰.

4.1.1 Labour tax cuts

The results (Table 1) show that using the carbon tax proceeds to cut labour taxes increases GDP (+1.9%), employment (+3.5%) and effective consumption (+1.5%) compared to the case without a carbon tax in 2004. The impact of this reform thus corresponds to a strong form of double dividend. The decomposition of the price variation of the composite good helps to understand the mechanisms at play (Table 2).

Recycling		labour tax cuts	lump-sum transfers
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%
Government expenditure		+5.4%	?
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*	TOTAL	+1.5%	+0.4%
	Poor (F0-5)	+1.1%	+5.1%
	Lower class (F5-35)	+1.2%	+2.7%
	Middle class (F35-65)	+0.9%	+0.2%
	Upper class (F65-95)	+1.8%	-0.9%
	Rich (F95-100)	+3.8%	-0.6%
	Gini index	+2.0%	-5.5%
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

*Fisher quantity index aggregating composite consumption, energy consumption and individualised government expenditure. This index accounts for a tax-induced +3.8% energy efficiency increase of household equipment.

Table 1: Macroeconomic and distributional impacts of a €300/ tCO_2 tax recycled in labour tax cuts or lump-sum transfers, compared to the case without a carbon tax.

Use of tax proceeds (€300/ tCO_2)	labour tax cuts
Producer Price of the composite good	-0.1%
Decreasing returns to scale and technical progress	+0.1%
Cost of energy	+1.6%
Net wages	+1.5%
Payroll taxes	-3.6%
Other	-0.6%

Table 2: Sources of variation of the composite producer price if carbon tax proceeds are used to cut labour taxes, compared to the case without a carbon tax

²⁰In our runs, we make the explicit assumption of a rebate taking the form of some lump-sum amount per consumption unit.

Despite a 1.6% increase in the cost of energy inputs, the price of the composite good declines: when labour taxes are cut, the decrease in costs more than compensates the direct increase of energy costs and the induced increase of net wages. By blocking the spread of rising production costs, lower labour taxes maintain 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 leading to 1.5%, 5.4% and 1.9% growth in household consumption, government expenditures, and investment²¹. The upward pressure on wages acts as a counterbalancing force. Wage increase stabilises at +1.5%. This contributes to increase the purchasing power of households. The performance of labour tax cuts is consistent with theoretical analysis: the cost of the reform is reduced if the tax is substituted to a particularly distortive pre-existing levy; the cost can be negative if the reform reduces the ‘deadweight loss’ of the initial overall tax system.

However, using tax proceeds to cut labour taxes exacerbates income inequality. The share of the poor and the lower class in household income decreases slightly (-0.01 and -0.02 points, cf. Table 1). Labour tax cuts induce more consumption inequality (cf. 2.0% increase of the Gini index) and bring down the consumption of the poor by 1.1%. Labour tax cuts increase inequalities because they raise the energy expenses of the poor substantially more than those of the rich, by 6 percentage points²². This simply reflects the fact that poor households, which are initially closer to their basic needs of energy services, have an elasticity of substitution between energy and the composite good that is lower than that of rich households.

The income distribution is also very sensitive to changes in the level of activity and therefore to the use made of tax revenues. This sensitivity stems from two main factors: the heterogeneity of the situation of households on the labour market and the diversity of non-labour income sources by class. On the one hand, large labour tax cuts already target lower wages, which limits the effect of a new tax reduction on the employment rate of the poor. Also, the poor and lower income classes are more sensitive to activity increases because their ex-ante unemployment rate is higher than that of other classes (21% for the poor and lower income class vs. 3.7% for the upper class and the rich). While the income of the richer classes varies more with a shift from

²¹Triggering this virtuous circle is certainly not systematic. It depends on a set of parameters and assumptions regarding the labour market and the proportion of the payroll tax rebate that translates 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.

²²This is not true for residential energy. The underlining cause is the existence of rebound effects: as rich households become substantially richer than the other classes, they increase their residential energy consumption more and pay a higher bill.

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 (+13.5% vs. +5.8%). Here the quantity effect dominates: even though the gap between wages and unemployment benefits is larger for the lower income groups than for the richer income groups, an increase in economic activity creates many more jobs for poor households than for rich households. On the other hand, capital income, positively correlated to the living standard, is growing faster than labour income in the labour-tax-cuts option (+14.5% vs. +7.8%)²³. The important point here is that revenues do not fluctuate in a homothetic way with GDP. There is a positive correlation between activity, property income and financial assets returns. When the economy is growing, 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 a contraction of the economy, because the decrease in interest rates is constrained by the fact that the repayment of the debt makes capital scarcer.

4.1.2 Labour tax cuts vs. lump-sum transfers

We now compare the effect of recycling tax revenues through labour tax cuts and lump-sum transfers. The comparison of both reforms (Table 1) shows that comparable levels of emission reduction (34.1% and 34.8%)²⁴ are achieved under opposite variations of GDP (+1.9% vs. -0.7%), and better performances in terms of employment (+3.5% vs. +0.3%) and effective consumption (+1.5% vs. +0.4%) for labour tax cuts.

As expected, lump-sum transfers are strongly progressive: the cumulated share of the poor, the lower and the middle class in disposable income increases by 0.96 points. This leads to a significant reduction of consumption inequality, as shown by the 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%). 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 taxes but receives a lump-sum transfer of €2,619—the balance amounting to 11% of its initial consumption budget; by contrast the average rich household receives a €1,060 balance that amounts to only 1.6% of its budget. Lump-sum transfers lead to lower economic growth (-0.7%), reduced employment

²³ 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.

²⁴ Note that rebating the tax proceeds to households through lump-sum transfers 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 in the case of lump-sum transfers.

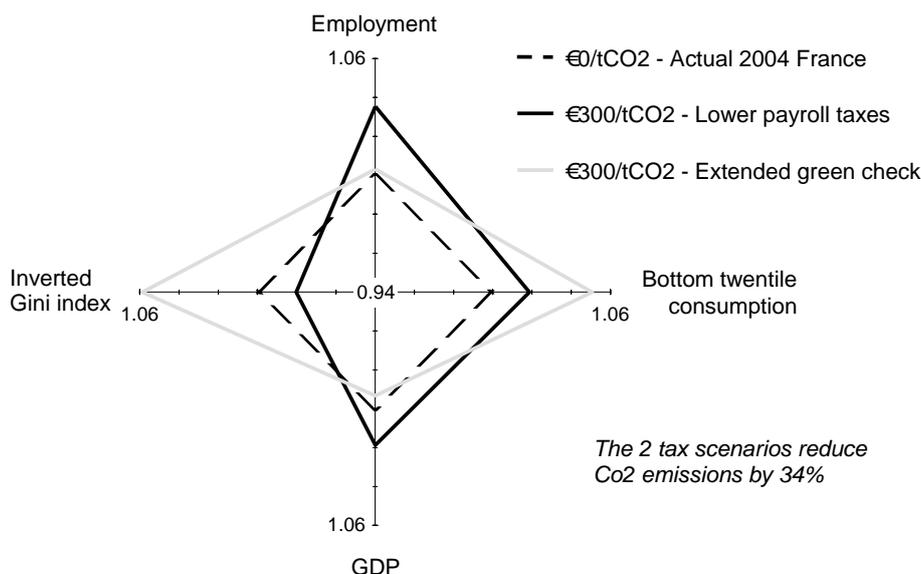
gains (+0.3% vs. +3.5% for labour tax cuts) and a contraction of investment (−0.7%). These adverse effects are mainly the result of rising production costs that spread through the economy as higher energy costs are not counterbalanced by lower labour costs. Rising production costs induce simultaneously a degradation of the terms of trade, and a decrease of the purchasing power of households. This translates into depressed demand for domestic products, causing unemployment to rise, which further degrades the purchasing power of households. This vicious circle is counterbalanced by the effective transfer of producers' tax payments to consumers, which acts as an implicit consumption aid. The overall propensity to consume also increases due to the very progressive income redistribution (a 'Kaldorian' effect). But this effect is not strong enough to cancel out the adverse impact of the reform on competitiveness and investment (−0.7%).

There is an equity-efficiency dilemma, which can be conveniently represented on a four-dimensional diagram, with two efficiency criteria (i.e. employment and GDP) on the vertical axis, and two equity criteria (i.e. the level of consumption of the poor (first twentile) and the inverse of the Gini index) on the horizontal axis. On this diagram, the historical situation of 2004 is represented by a dashed black diamond with an index of 1 on the four criteria. Recycling a €300/ tCO_2 tax to cut labour taxes does not benefit equity but is far more efficient than lump-sum transfers (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.

Comparing the net distributional effect of alternative policy options is not straightforward. Similarly to most studies focusing on industrialised countries, our results show that the redistributive effect of a uniform labour tax cut does not offset the regressive effect of higher energy bills. By contrast, the direct redistribution resulting from uniform lump-sum transfers can narrow inequalities, although at the cost of lower employment and production. It is therefore important to consider how the reform may affect the purchasing power that remains after the payment of energy bills.

4.2 Hybrid revenue recycling schemes

We now consider three hybrid revenue recycling schemes which may strike a compromise between economic efficiency and equity objectives. All proposals include a system of direct compensation to households which preserves the environmental efficiency of price signals. Funds that are not



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 1: Synthetic view of the equity and efficiency performance of labour tax cuts vs. lump-sum transfers ($\text{€}300/t\text{CO}_2$ tax)

used to finance direct compensation are recycled in labour tax cuts—under the constraint of a constant public debt to GDP ratio. The proposals are the following (in order of decreasing share of tax proceeds allocated to labour tax cuts), and their performances are summarised in Table 3.

- A generalised tax credit option 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 twentile²⁵. This earmarks a large share of the tax proceeds for labour tax cuts.
- A targeted tax credit with accompanying measures restricts the previous tax credit to the 80% lower-income households, devotes the remaining tax proceeds to labour tax cuts, and finances (on the remaining budget margin²⁶) additional measures for the households that combine poverty and dependence on fossil fuels²⁷. These measures include the accelerated provision of energy efficient equipment (building, heating, household appliances) and dis-

²⁵ The percentage is computed to cover the average annual daily commute to work of French households.

²⁶ Under the maintained constraint of constant public debt to GDP ratio.

²⁷ Modelled as a transfer decreasing with income and limited to the 80% lower-income households. The impacts on energy efficiency are not considered.

counts 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.

- A mixed recycling option where a restricted green check option rebates to households the tax levied on their energy expenses only²⁸, on a fixed per-consumption-unit basis. The carbon tax levied on production is thus recycled in labour tax cuts. This ‘mixed recycling’ option has the advantage of circumventing the dispute over the sharing of the tax proceeds between households and firms.

Type of direct compensation		Generalised tax credit (1)	Targeted tax credit (2)	Mixed recycling (3)
Share of tax proceeds to lump-sum transfers		+16.3%	+24.3%	+42.8%
Producer price of the composite good		-0.2%	+0.3%	+1.3%
Variation in percentage points				
Share of household disposable income	Poor (F0-5)	+0.0	+0.1	+0.1
	Lower class (F5-35)	+0.1	+0.4	+0.4
	Middle class (F35-65)	-0.1	+0.1	-0.0
	Upper class (F65-95)	-0.2	-0.5	-0.4
	Rich (F95-100)	+0.1	-0.0	-0.1

F# - # : fractiles of standard of living (F0-5 : 5% of the poorest households, etc.).

Table 3: Macroeconomic and distributive performance of three hybrid revenue recycling schemes (€300/tCO₂ tax).

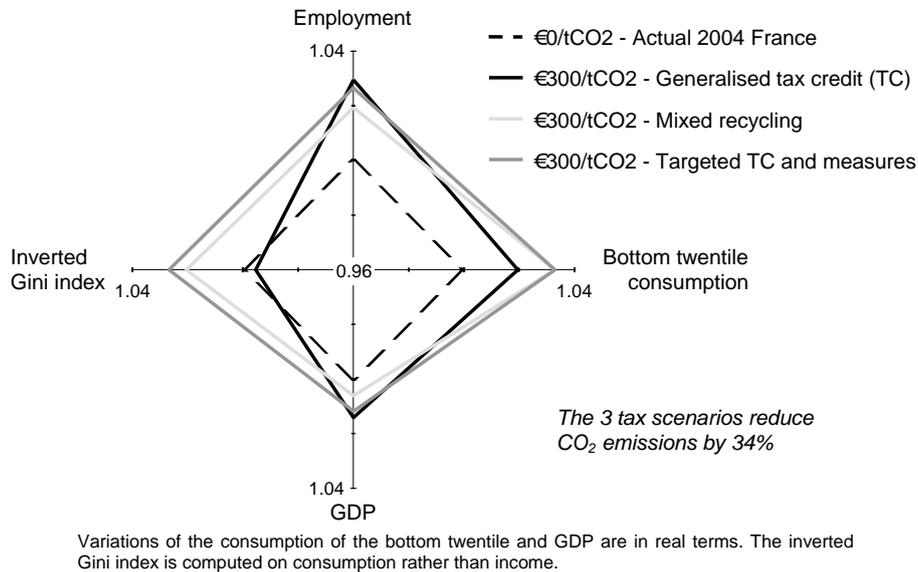


Figure 2: Figure 2: Synthetic view of the equity and efficiency performance of three hybrid recycling options (€300/tCO₂ tax)

Two of the three proposals perform better than the historical situation on the four synthetic

²⁸The VAT compounded on the carbon tax is also redistributed.

dimensions (Figure 2). 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 compensated by the performance of the scheme in terms of employment and activity, particularly relative to the targeted tax credit with accompanying measures. The targeted tax credit with accompanying measures and the mixed recycling option 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 resources dedicated to its funding (Table 3). The larger these resources, the lower the transfer of the fiscal burden from domestic production to non-wage income, hence the lower the decrease in production costs. It is thus no wonder that the mixed recycling option has a higher cost than the targeted tax credit and measures option, as 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. The targeted tax credit and measures option restricts the compensation to more vulnerable households for a higher equity impact and at a lower financing cost (only 26.5% of the proceeds). It also favours the middle class, which is more vulnerable to the carbon tax in the other two options (its share of household disposable income rises by 0.1 points)²⁹. Finally, our simulations do not account for one additional advantage of the targeted tax credit and measures: the fact that it can target cases of energy vulnerability that are not strictly correlated to income levels but to other factors (e.g. 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.

4.3 Inequalities and social welfare

The diamond-shaped figure is a useful way to illustrate the performance of policies along multiple dimensions and strike a balance between efficiency and equity objectives in policy debates. Another, more conventional, way to assess the performance of policies would be to compute aggregate social welfare according to a given social welfare function. Of course, the ordering of policies is sensitive to the type of social welfare function used. We consider here two social welfare functions³⁰, translating two contrasted views on the acceptable degree of inequalities in

²⁹The 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.

³⁰Aggregate social welfare is equal to the sum of the average utility of households of each income class, weighted by the number of households in each class (N_h) and by a social weight (σ_h) assigned to that income class. $W_h^s = \sum_h N_h \cdot \sigma_h \cdot U_h^s = \sum_h N_h \cdot \sigma_h \cdot \ln(c_h/N_h)$. The variation of aggregate social welfare is given by

society: (i) one social welfare function puts equal weights³¹ on all income classes (i.e. the utility of all individuals contributes to social welfare in the same way), and is labelled ‘equal social weights’ in table 4; (ii) the other uses Negishi weights³² (i.e. the initial distribution, without carbon tax, is optimal), and is labelled ‘historical distribution’ in table 4. The results show that the best policy depends on the acceptable degree of inequalities from a societal point of view: Labour tax cuts should be preferred if the historical (2004) distribution of utility is considered optimal, while the hybrid revenue recycling option performs better if the utility of all individuals is weighted equally. The impact of the recycling options on the actual distribution of wealth is rather small, but the impact of the redistribution on aggregate welfare still depends on the type of welfare function considered. Table 4 shows the contribution of productive efficiency and the contribution of the redistribution to total aggregate welfare³³ for both social welfare functions and both recycling options.

If the performance of the policies is judged against the ‘historical distribution’ welfare criterion, the contribution of redistribution is very small for both recycling options. The impact of policies on redistribution has a greater impact when using the ‘equal social weights’ welfare criterion to assess the performance of policies. In that case, hybrid recycling performs better than labour tax cuts in terms of redistribution, as hybrid recycling increases the consumption of the poorest households³⁴. Note that the impact of redistribution on aggregate welfare is obtained for a given type of household disaggregation. The impact of distribution on aggregate welfare could be higher if one assumed a different, finer disaggregation, emphasizing the fact that a few very vulnerable households are severely hit by the carbon tax.

4.4 Sensitivity analysis

We explore the sensitivity of the results to assumptions on the flexibility of wages and on the terms of trade. We then examine the impact of the type of equity considered (vertical vs. horizontal) on the results. In the results presented above (thereafter called the central case),

$$\Delta W = W_h^F / W_h^0 - 1.$$

³¹ $\sigma = 1$ for all income classes

³² Adapted from (Negishi, 1960), i.e. the weights are set to be equal to the inverse of the marginal utility of consumption for each income class.

³³ The contribution of productive efficiency to the variation of aggregate welfare is obtained as the variation of welfare between the initial state (without a carbon tax) and a state where the final level of aggregate consumption is reached while the distribution of wealth among classes has not changed. The contribution of redistribution to the variation of aggregate social welfare is obtained as the variation of welfare between that previously mentioned state and the final state where both the final level of aggregate consumption and the distribution of wealth has changed.

³⁴ Although in that case hybrid recycling increases global inequalities as measured by the Gini index.

Recycling scheme	labour tax cuts	hybrid
Equal social weights		
Aggregate social welfare variation	+0.584%	+0.617%
(i) Contribution of productive efficiency	+0.518%	+0.424%
(ii) Contribution of redistribution	+0.066%	+0.192%
Historical distribution (2004)		
Aggregate social welfare variation	+0.511%	+0.418%
(i) Contribution of productive efficiency	+0.512%	+0.420%
(ii) Contribution of redistribution	-0.001%	-0.001%

Table 4: Influence of the definition of a social welfare function on the ordering of policies

Trade: central case	-10% elasticity of wages (central case)			Fully flexible wages			Fixed real wages		
	labour tax cuts	lump -sum	hybrid	labour tax cuts	lump -sum	hybrid	labour tax cuts	lump -sum	hybrid
Employment	+3.5	+0.3	+2.7	+0.0	+0.0	+0.0	+10.2	-11.5	-3.2
Real GDP	+1.9	-0.7	+1.2	+1.0	-0.9	-0.9	+7.4	-10.0	-3.5
Gini index	+2.0	-5.5	-2.6	+3.1	-5.2	+2.7	+0.4	+9.4	+9.4
Cons. of the poorest 5%	+1.1	+5.1	+3.3	-1.6	+4.6	-1.3	+6.8	-12.5	-6.8
(a)			(b)			(c)			
Trade: relatively closed economy	-10% elasticity of wages (central case)			Fully flexible wages			Fixed real wages		
	labour tax cuts	lump -sum	hybrid	labour tax cuts	lump -sum	hybrid	labour tax cuts	lump -sum	hybrid
Employment	+3.1	+2.0	+2.8	id.	id.	id.	+1.5	-1.8	+1.0
Real GDP	+1.4	+0.9	+1.3	-0.2	-0.1	-0.2	+0.6	-1.0	+0.3
Gini index	+2.0	-6.3	-2.9	+4.7	-1.7	+6.5	+3.4	+2.7	+3.1
Cons. of the poorest 5%	+0.5	+7.8	+3.6	+0.1	+5.0	-0.8	+0.3	+2.4	+0.8
(d)			(e)			(f)			
Trade: relatively open economy	-10% elasticity of wages (central case)			Fully flexible wages			Fixed real wages		
	labour tax cuts	lump -sum	hybrid	labour tax cuts	lump -sum	hybrid	labour tax cuts	lump -sum	hybrid
Employment	+3.8	-0.7	+2.6	id.	id.	id.	+8.9	-18.3	-6.2
Real GDP	+2.1	-1.6	+1.1	-1.0	-1.0	-1.0	+6.4	-16.3	-6.2
Gini index	+2.0	-5.0	-2.4	+2.9	-5.7	+2.2	+0.8	+15.1	+14.3
Cons. of the poorest 5%	+1.4	+3.5	+3.1	-1.9	+4.5	-1.4	+9.5	-23.1	-12.3
(g)			(h)			(i)			

Table 5: Sensitivity analysis – Summary of results

we assumed an elasticity of nominal wages to the unemployment rate of -0.1, a domestic price elasticity of exports of -0.06 and a domestic price elasticity of imports of 0.01, and a balanced government budget (i.e. no debt creation). The results of the sensitivity analysis are summarised in table 5.

4.4.1 The influence of the flexibility of wages on efficiency

Labour tax cuts are clearly superior to lump-sum transfers in terms of employment and GDP in the central case (table 5a), i.e. when the elasticity of wages to the unemployment rate is set at -0.1. Here we examine two polar cases: one assuming fully flexible wages, the other assuming fixed real wages. We assume an unchanged constraint on the government budget balance and

unchanged terms of trade compared to the central case (cf. above).

When wages are fully flexible (table 5b), all recycling strategies have comparable effects on employment and GDP. Fully flexible wages maintain full employment, and the nature of the tax reform has no effect on aggregate indicators. Note that in that case, lump-sum recycling is unambiguously superior to labour tax cuts, as it performs better along the distributive dimensions. These results are in accordance with those of [Proost and Regemorter \(1995\)](#)³⁵.

When real wages are fixed (table 5c), the recycling options perform very differently in terms of employment³⁶ and GDP, as cutting labour taxes is clearly superior to lump-sum transfers along these dimensions. With fixed real wages, the carbon tax that would otherwise weigh on households through a higher consumer price index is shifted to firms' production costs as to keep real wages constant. Real-wage costs increase as a result. This increase, combined with higher energy costs, may lead to a lower profitability of firms. Higher prices ensue to preserve profitability, which has a depressive effect on demand and investment, and unemployment surges. This effect is mitigated if tax revenues are recycled to cut labour taxes, but not so much if tax revenues are recycled through lump-sum transfers. Here again, the result is in accordance with ([Proost and Regemorter, 1995](#)). The drop in activity is particularly large if domestic producers face international price competition, as we illustrate below. Note that the relative performance of both recycling options along the distributive dimensions may vary depending on the constraint imposed on the debt to GDP ratio. This issue will be examined at the end of this section. Contrary to the results of [Proost and Regemorter \(1995\)](#) recycling tax revenues through labour tax cuts can increase GDP under fixed real wages. This is due to the fact that despite fixed wages, production costs are allowed to decrease via the taxation of non-wage income. Lower production costs improve the trade balance and boost GDP³⁷. The order of magnitude of this effect depends on assumptions on the way the constraint on public debt is implemented and on the relative price elasticity of exports and imports.

³⁵Note that the results are the same whether we consider real or nominal wages (i.e. whether wages are divided by the Consumer Price Index (CPI) or not).

³⁶Note that in that simulation, export gains are capped to 5.7% to ensure that unemployment does not reach negative values.

³⁷However, lower domestic non-energy demand due to high energy expenditures can partly compensate the increase in GDP.

4.4.2 The influence of the terms of trade on equity

In an open economy, an increase in domestic production costs leads to higher domestic prices, hence lower exports, higher imports, and possibly lower employment and GDP, which may in turn indirectly impact the distribution of wealth. Here we examine two polar cases, one assuming a less open economy (i.e. price elasticities of imports and exports both reduced by 1/3 compared to the central case), the other assuming a more open economy (i.e. price elasticities of imports and exports both increased by 1/3 compared to the central case). We assume an unchanged constraint on the government budget balance and unchanged flexibility of wages compared to the central case (cf. above).

Labour tax cuts were already superior to lump-sum transfers in terms of employment and GDP in the central case (table 5a): the contrast between both recycling options increases in an open economy (table 5d). Indeed, labour tax cuts help maintain low production costs and low domestic prices, which are crucial to sustain high GDP and employment in an open economy where domestic producers face international competition. In terms of distributive parameters (Gini index and consumption of the poorest households), labour tax cuts were inferior to lump-sum transfers in the central case (table 5a), but the gap between both recycling options narrows in an open economy (table 5d). Although lump-sum transfers directly redistribute wealth, they also bring lower aggregate levels of employment and GDP than labour tax cuts, which may indirectly impact the ultimate distribution. The distributive indicators are therefore influenced by both direct and indirect mechanisms. In an open economy, the second effect is strong, as lump-sum transfers do nothing to reduce production costs and sustain demand.

By contrast, in a relatively closed economy (table 5g), the trade-off between controlling production costs (achieved by labour tax cuts) and redistributing wealth is less compelling than in the central case. Indeed, the mechanism that would damage the competitiveness of domestic firms when those are hit by a carbon tax is mitigated when assuming a lower price elasticity of imports and exports.

It is also interesting to examine cross effects of assumptions on wage flexibility and on the terms of trade. Under fixed real wages, salaries and production costs are high, which may hamper international competitiveness, hence demand, GDP and employment. Labour tax cuts can mitigate this effect and are therefore superior to lump-sum transfers in terms of aggregate results. While in the central and fully flexible wages cases, lump-sum transfers were always superior to labour tax cuts along the distributive dimensions, the results are different when real

Trade: central case Wages: fixed real wages	Constrained public deficits (central case)			No constraint on public deficits		
	labour tax cuts	lump-sum	hybrid	labour tax cuts	lump-sum	hybrid
Employment	+10.2	-11.5	-3.2	+0.1	-3.0	-0.5
Real GDP	+7.4	-10.0	-3.5	+0.7	-1.8	-0.9
Gini index	+0.4	+9.4	+9.4	+3.7	-0.2	+2.3
Cons. of the poorest 5%	+6.8	-12.5	-6.8	-0.7	+6.3	+0.8
debt/GDP	0.0	0.0	0.0	+23.7	+259.2	+43.7

(a)

(b)

Table 6: Sensitivity analysis – Impact of the constraint on the debt to GDP ratio

wages are fixed. In this context, the relative performance of both recycling options along the distributive dimensions varies depending on the terms of trade. The impact of fixed real wages on demand depends on the level of international price competition faced by domestic producers. In a relatively open economy, the assumption of fixed real wages has a great impact on demand, which indirectly impacts the consumption of the poorest households. This indirect distributive effect counterbalances the direct distributive effect of lump-sum transfers on the consumption of the poorest households. In the case of a relatively open economy, the hybrid option no longer strikes a compromise between the polar recycling cases.

When real wages are fixed (table 5c), it is interesting to note that cutting labour taxes is superior to lump-sum transfers along distributive dimensions too. In that case and that case only, lump-sum transfers reduce the consumption of the poorest households compared to the case without a carbon tax (except for a relatively closed economy). As mentioned above, there can be a large drop in activity when domestic producers face international price competition. The subsequent drop in revenues erodes the tax base, and lump-sum transfers can become negative to balance the public budget. When lifting the constraint of a balanced public budget (i.e. allowing for public debt, cf. table 6b), lump-sum transfers perform again better than labour tax cuts in terms of redistribution.

Some general results emerge from the sensitivity analysis. First, when wages are fully flexible, lump-sum transfers are always superior to labour tax cuts (and to hybrid recycling options), whatever the terms of trade. This is due to the fact that full employment is guaranteed by assuming fully flexible wages, and the advantage of labour tax cuts over lump-sum transfers in terms of employment does not play. Second, when real wages are fixed, labour tax cuts are always superior to lump-sum transfers in terms of employment and GDP, and also superior in terms of redistribution in the case of a relatively open economy. Indeed, lump-sum transfers perform worse along the distributive dimensions in an open economy due to the indirect dis-

Trade and wages: central case	Vertical equity (20 income groups)			Trade and wages: central case	Horizontal equity (6 territorial groups)		
	labour tax cuts	lump-sum	hybrid		labour tax cuts	lump-sum	hybrid
Employment	+3.5	+0.3	+2.7	Employment	+3.6	+0.3	+2.6
Real GDP	+1.9	-0.7	+1.2	Real GDP	+1.9	-0.7	+1.1
Gini index	+2.0	-5.5	-2.6	Gini index	+13.4	+35.9	+17.0
Consumption of the poorest 5%	+1.1	+5.1	+3.3	Consumption of rural households	+0.0	-4.0	-1.9

(a)

(b)

Table 7: Sensitivity analysis – Impact of the type of distribution considered on policy performance
tributive effects of higher employment and GDP on the consumption of the poorest households.

4.4.3 Vertical equity vs. horizontal equity

Inequalities in terms of non-income dimensions have been little analysed in the literature. These horizontal inequalities are important when dealing with energy issues, as geographical differences, equipment, the energy efficiency of building are not well correlated with income but crucially impact energy vulnerability and energy poverty (Dubois, 2012). Here, we explore the sensitivity of the results on the way households are aggregated into various groups in the analysis. While the central case (labelled ‘vertical equity’ below) focused on measuring inequalities among twenty income groups, we now consider the case where households are aggregated into six territorial groups, according to the degree of urbanization, from households in rural areas to households in very dense cities (labelled ‘horizontal’ equity below). These two different set-ups are implemented in the same modelling framework.

The results show very similar results in terms of employment and GDP (comparing tables 7a and 7b, row by row)³⁸. By contrast, the results greatly differ along equity indicators, due to contrasted consumption patterns between households in rural and urban areas. Indeed, the share of energy expenditures in the budget of households varies more according to the degree of urbanization (between 2.5% and 9.5%) than according to income (between 5.3% and 8.5%, cf. table 8).

In the case of horizontal equity, both lump-sum and hybrid recycling increase inequalities (higher Gini index and lower consumption of rural households) compared to labour tax cuts. This result may seem counter-intuitive at first, as the main reason behind the introduction of lump-sum transfers is to reach a more equitable distribution of wealth. It is due to the fact that none of the revenue recycling options distinguishes between rural and urban households. Lump-sum

³⁸This second order effect of income distribution on aggregate indicators is due to the fact that there is no geographical segmentation of the labour market in the model.

Degree of urbanization	Share of budget to energy expenditures	Income group	Share of budget to energy expenditures
Rural	9.46%	Poor (F0-5)	8.50%
Urban (<20 000 inhab.)	8.05%	Lower class (F5-35)	8.22%
Urban (20 000 à 100 000 inhab.)	6.95%	Middle class (F35-65)	7.79%
Urban (>100 000 inhab.)	6.06%	Upper class (F65-95)	6.29%
Greater Paris region (excl. Paris)	4.73%	Rich (F95-100)	5.26%
Paris	2.54%		

(a)

(b)

Table 8: Share of budget allocated to energy expenditures, by degree of urbanization and income group

transfers are very small compared to the burden of the tax on rural households, who may disproportionately suffer from the low performance of that type of revenue recycling in terms of GDP and employment. This sensitivity analysis shows that it is paramount to identify the most vulnerable households and define the criteria used to award lump-sum transfers accordingly to reach a more equitable distribution of wealth.

5 Conclusion

This paper examines the macroeconomic and distributive impacts of a carbon pricing reform. The contributions are twofold. On the one hand, we propose a comprehensive analytical framework encompassing modern macroeconomics, public economics of taxation and energy and environmental economics. On the other hand, we provide new insights on the efficiency vs. equity trade-offs of carbon pricing policies in the context of an open economy with the case study of France.

We analyse an alternative widely debated for the use of carbon tax revenues: lump sum transfers vs. cuts in existing distortionary taxes. The dilemma between lump-sum transfers and labour tax cuts boils down to a trade-off between controlling production costs and redistributing wealth directly. When carbon tax revenues are recycled through lump-sum transfers, rising production costs due to higher energy costs are not counterbalanced by lower labour costs, which brings lower GDP and employment. We show that, except in very particular macroeconomic contexts (e.g. an economy described either by a walrasian flexible-price model or by a fixed-price model) and with clear-cut ethical goals (e.g. zero aversion to income inequality), the macroeconomic and distributive consequences of carbon price policy are intertwined. Therefore, equity and efficiency cannot be treated separately. In practice, the adverse distributive consequences of the carbon tax cannot be dealt with lump-sum redistribution alone. Conversely, the adverse macroeconomic impact of the carbon tax cannot be mitigated solely by reducing pre-existing

taxes.

In a relatively open economy with a non-clearing labour market (as illustrated by the case study of France), hybrid recycling options can strike a compromise between equity and efficiency by redistributing some wealth through lump-sum transfers while using the remaining carbon tax revenues to cut labour taxes. The best hybrid recycling option devotes the bulk of tax revenues to labour tax cuts, while directly compensating only the most vulnerable households. This option reduces the existing tax burden bearing on production costs, which minimises the propagation of higher costs through the economy and favours aggregate demand, employment and the trade balance. At the same time, direct compensatory transfers to the most vulnerable households increases their consumption and reduce inequalities.

The sensitivity analysis shows that the terms of the equity-efficiency dilemma and the hierarchy of the revenue recycling options crucially depend on the macroeconomic context (e.g. the level of nominal and real rigidities in the labour market, the sensitivity of external trade to prices). For instance, the gap between the performance of recycling options widens in situations where limiting the increase of production costs due to the carbon tax is particularly crucial. This is the case in an open economy, where it is paramount to control domestic production costs as domestic producers face international competition (i.e. with a high sensitivity of external trade to prices). The effect of the terms of trade can be large, also depending the level of nominal and real rigidities in the labour market. Finally, the hierarchy of revenue recycling policies depends on the type of inequalities considered. Uniform transfers may not reduce inequalities between households living in urban and rural areas. It is therefore paramount to identify the most vulnerable households and to define the criteria used to award lump-sum transfers accordingly.

We conclude that no revenue recycling option is universally superior to another: there is no one-size-fits-all policy. Further research is therefore needed to perform other case studies that account for specific macroeconomic and national contexts. Such analyses would be a very useful contribution to the ongoing discussions on how energy transition policies and nationally determined contributions (NDC) can be brought in line with national development goals.

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