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Emmanuel Combet - Gaëlle Le Treut - Aurélie Méjean - Antoine Teixeira

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

Emmanuel Combet[a], Gaëlle Le Treut[b], Aurélie Méjean[c], Antoine Teixeira[d]

a- ADEME
b- ENPC, CIRED
c- CNRS, CIRED
d- ADEME, CIRED

Abstract

This paper examines the macroeconomic and distributive impacts of carbon pricing reforms. We carry out an analysis encompassing modern macroeconomic, public economics of taxation and energy and environmental economics considerations. 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 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; General Equilibrium

JEL Classification: C68; Q50; H23; D63

1. Introduction

In Paris 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 (World Bank, 2016), and many countries have already implemented carbon pricing in the form of tradable emission permits or carbon taxation (World Bank, 2020)[1].

Carbon pricing has been consistently prescribed by economists as an efficient way to mitigate climate change since at least Pearce (1991), and the importance of filling its implementation gap has been stressed (High-Level Commission on Carbon Prices, 2017). Over the past 20 years, carbon pricing 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 households, or if 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 its implementation is often hindered by disagreements about how to best use the associated revenues (Klenert et al., 2018a).

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 revenues directly to household through lump-sum transfers. This is because cutting distortionary taxes may be superior in terms of allocative efficiency, i.e., in terms of employment, private income and welfare (Goulder, 2013). It may thus also improve the economic situation of some vulnerable households. 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 (Klenert et al., 2018a). Various schemes of monetary transfers to households can be applied: uniform transfers distributed to the whole population (popularized as “carbon dividends” by the Climate Leadership Council; see Akerlof et al., 2019), or more targeted and differentiated transfers that compensate the vertical (income-related) and horizontal (non-income related) distributive impacts of carbon prices (Douenne, 2020). A number of behavioural economics studies have also emphasized that lump-sum transfers may be preferred to cutting distortive taxes as the former may increase public support for carbon taxation (Carattini et al., 2019, 2017; Douenne and Fabre, forthcoming; Kallbekken et al., 2011; Maestre-Andrés et al., 2019). A higher efficiency cost may therefore be deemed necessary for political acceptability reasons.

The choice of the best revenue-recycling strategy thus relates to a challenging problem of public economics, namely how to design an environmental policy that is both efficient and equitable. This issue has been the topic of a large and still growing body of literature on

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

"second-best" policies. Real world problems and climate policies interact. It is therefore crucial to acknowledge the second-best nature of the issues at hand, in order to design policies that account for synergies and trade-offs between climate and non-climate issues (Sterner et al., 2019; Stiglitz, 2019). This is the only way to sustainably address the many fairness and political economy issues raised by the introduction of an environmental reform, as demonstrated by the successive rejections of carbon taxation due to equity and competitiveness concerns, for instance during the 2018 Yellow Vests protests in France (Douenne and Fabre, forthcoming).

An extensive public finance literature (see Stiglitz (2019) and section 2 below for a non-exhaustive literature review) shows that the optimal tax policy greatly depends on (i) the set of ethical judgements used to define the societal objective (e.g., environmental quality, public good provision, private consumption, inequality reduction), and (ii) the economic model used to describe the effects of alternative policies on that objective (e.g., the functioning of markets, income distribution, and the availability of public information, policy instruments, and budgetary leeway to undo the distributive consequences of carbon pricing). As economists have come to consider a wider variety of assumptions in their models, the consensus on the best strategy to use carbon tax revenues has actually weakened over time. We propose a way forward that acknowledges the lack of consensus on these issues. We take two major steps:

(1) We assume a deliberative process of decentralised decision and collective bargaining in which the ethical judgements used by society to design a tax reform will only be revealed as the democratic debate unfolds[2]. In this context, the analyst does not know the model that would allow her to optimise welfare and conclude on *the* second-best optimal policy. Instead, we provide an economic analysis that disentangles the influence of ethical values and of parameters that govern the functioning of the economy on the evaluation of policy (Combet, 2020). We assume a well-informed process of collective decision in which stakeholders have agreed on a range of evaluation criteria and perform a multi-criteria analysis to find the best revenue-recycling options. In our case study, we discuss the choice of our indicators, as well as the importance of considering non-income dimensions of inequalities (horizontal equity).

(2) We recognise the importance of the context (the national and period specificities) and that alternative beliefs and views co-exist about the functioning of the economy. The analyst can conduct sensitivity tests to clarify how different plausible assumptions made by stakeholders and different national contexts change policy evaluation. Our analysis highlights the role of two crucial assumptions in post-crisis open economies: the existence of nominal and real wage rigidities in the labour market and the sensitivity of external trade to the terms of trade. These macroeconomic assumptions affect the hierarchy of alternatives to recycle tax revenues.

We apply this approach to the case study of France, using a static numerical model. We show that, except in very particular macroeconomic contexts, the aggregate and distributive

2 The exact process will depend on the political and institutional context.

consequences of policies are intertwined. We highlight that the dilemma between the equity and the efficiency of the carbon tax policy boils down to a trade-off between controlling production costs and redistributing wealth directly to households. In most modern macroeconomic contexts, hybrid recycling options can strike a compromise between equity and efficiency by redistributing some wealth through lump-sum transfers to compensate directly the most vulnerable households, while using the remaining revenue to alleviate the impact of carbon pricing on production costs. We highlight that a balance can be found between two objectives: (1) limiting the negative impacts of higher energy costs, otherwise particularly damaging for a domestic economy facing harsh international competition; (2) preserving the purchasing power of some parts of the population, i.e., those particularly vulnerable to high energy prices in the short to medium run. A right balance has to be found in each policy context. This balance, and the resulting definition of the best strategy to use tax revenues, depend on the assumptions made about the rigidities of wages and the terms of trade. They also depend on the public information made available about the most vulnerable households. In particular, uniform transfers may be progressive according to the poor-rich axis, but nevertheless inequitable, since they may not reduce inequalities between households living in urban and rural areas. We conclude that no revenue recycling option is universally superior to another, and that more case studies should be carried out to account for specific national (macroeconomic and distributional) contexts.

The paper is structured as follows. Section 2 presents a brief literature review. Section 3 describes the analytical framework. Section 4 examines the performance of various options to recycle tax revenues in the case of France: 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 a range of contextual parameters. Section 6 concludes.

2. Literature review: The equity-efficiency trade-off in a second-best world

When assuming perfect markets and a perfect information economy, public administrations can always finance public goods and redistribute wealth by using non-distortionary lump-sum transfers. In the case of environmental pricing, an environmental tax should thus be set to match environmental considerations only (Pigou, 1932), and equity is restored by organizing transfers from the winners to the losers. However, this first-best world does not exist. In reality, public administrations cannot apply non-distortionary lump-sum transfers because their implementation would require full information on individual situations. The issue of the trade-off between the equity and the efficiency of tax revenue recycling originates from this lack of public information. The modern analysis of public pricing has come to represent this trade-off in a realistic way with Mirrlees (1971). If public administrations cannot rely on perfect lump-sum transfers, they must design other tax instruments (or a combination of price and non-price policy instruments) in a way that balances the goals of environmental protection, public good provision, private welfare and distributional equity (Sandmo, 1975; Cremer et al., 1998; Cremer et al., 2003; Stiglitz, 2019). Introducing a new environmental tax component provides additional public revenue that can be recycled to finance reductions in other distortive taxes. Therefore, reconciling equity, efficiency and environmental objectives supposes that the implementation of a larger public finance reform is feasible and that the direct and indirect distributive impacts of a uniform carbon price can be addressed as part of that wider reform (Stiglitz, 2019)[3].

The adjustment of the optimal tax system has proved to be highly sensitive to the initial situation, which affects the comparison of alternative revenue recycling options - the best option being simply the one that reduces the most harmful initial inefficiencies and inequities. If the initial income tax schedule redistributes optimally between households and generates revenue, the option of reducing income tax rates does not necessarily outperform uniform lump-sum redistribution (Jacobs and de Mooij, 2015; Klenert et al., 2018b). However, if the initial income tax schedule is suboptimal (for instance if the labour tax system is suboptimal), substituting part of this taxation for higher energy taxes may enhance both equity and efficiency (Klenert et al., 2018b; Chiroleu-Assouline and Fodha, 2014). Many in-between situations can be designed to fit specific contexts. The great diversity of models and analyses now available in the literature has led to a diversity of policy recommendations.

In the early 90s, the political claims that substituting labour taxes for energy taxes could yield a 'double dividend' by enhancing the efficiency of economies beyond reducing their impacts on the environment motivated a large body of literature – see Goulder (1995), Bovenberg (1999) and Goulder (2013) for reviews. Much of this work however rests on the assumption of a representative consumer. That literature stresses that a carbon tax, by increasing production costs and the living costs of consumers, contributes to increasing pre-existing tax distortions on labour supply or labour demand. As a consequence, the best recycling option is not to redistribute revenues through lump-sum transfers (even when non-distortionary transfers are possible), but to reduce other taxes that distort employment choices (labour or capital taxes). The difficulty comes from the fact that the disincentive effect on labour itself depends on the assumed functioning of the labour market, which is uncertain and debated.

Assuming a competitive labour market, early analyses have found that increasing energy taxes is somewhat equivalent to increasing labour taxes (Bovenberg and 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. Consequently, with a competitive labour market, employment can increase only if labour supply is less sensitive to energy taxes than it is to labour taxes. The subsequent literature departed from the Walrasian model of the labour market by introducing various non-competitive features and other sources of income than labour (social transfers, rents from fixed factors of production). A wider range of possible impacts on employment and wages emerged from these analyses. Overall, tax substitution can cut unemployment if it shifts the tax burden to those individuals whose

3 Stiglitz (2019) provides a comprehensive review of the multiple market failures and public policy constraints studied in modern public finance theory and their implications for equity, efficiency, and the design of climate policies.

actions will contribute the least to a contraction of labour supply or demand[4]. As a whole, these analyses showed the great sensitivity of the aggregate efficiency impacts of the recycling option to the choice of the labour market model.

These general equilibrium mechanisms, although seen through the lens of aggregate efficiency indicators, always involve a redistribution of the tax burden from some individuals to others. The assumption of a representative consumer - as opposed to the assumption of a continuum of individuals in Mirrlees' types of model - makes it impossible to analyse the trade-off between aggregate and distributive impacts. Larger numerical models have been designed to include various income classes into complex general equilibrium systems. Using such a model, Proost and Regemorter (1995) show that the hierarchy between recycling options (a uniform cut of labour taxes on the one hand, a uniform lump-sum redistribution to income classes on the other) was sensitive to both the aversion for inequalities and the macroeconomic regime, and in particular to the level of real wage rigidities. Numerical analyses of this type, applied mainly to Anglo-Saxon contexts, display an equity-efficiency trade-off (Rausch et al., 2011; Goulder et al., 2019). Labour and capital tax reductions perform best with respect to aggregate indicators, while lump-sum transfers - in particular transfers directed to vulnerable groups - perform best in terms of distributional indicators. However, most of that literature uses neoclassical models of the market economy and continues to focus on the long term[5], while in policy discussions, the trade-off between equity and efficiency is more acute in the short to medium term, i.e., when limitations remain on the efficiency of price signals (significant labour market rigidities, physical capital inertia and dependence on fossil fuels).

By contrast, microsimulation exercises describe in details the redistributive effects of policies, building on income and expenditure surveys. These studies demonstrate that lump-sum redistribution to households, if well-designed, can compensate entirely the regressive effect of a carbon tax (for applications to the case of France, see Berry, 2019; Douenne, 2020). However, these partial equilibrium exercises consider the issue as a zero-sum game as they ignore general equilibrium mechanisms such as the effect of rising production costs on prices, which should really be accounted for to assess the opportunity cost of lump-sum recycling.

This bird-eye view of the literature illustrates important connections between the issue of the design of a carbon price policy and more general considerations about public finance, macroeconomics and distribution. The literature on carbon pricing however is still largely organised in silos, with little relation with modern macroeconomics. In particular, two strands of the macroeconomics literature can be related to our issue, as they bring other insights into

4 In particular, in neoclassical microeconomic analyses, this result is obtained when the tax burden is shifted unto the unemployed, thereby reducing the effective replacement rate (Bovenberg, 2003). For instance, Koskela and Schöb (1999) propose a bargaining model of the labour market where lower real unemployment benefits reduce the outside options of workers, who accept lower real wages. This allows employment to increase with labour demand. However, other microeconomic mechanisms exist in the literature. Employment can also expand if the tax burden is shifted to fixed factor income (Bovenberg, 1999).

5 An exception is (McKibbin et al., 2012).

the mechanisms described above. A first strand of literature analyses the macroeconomic response to energy price shocks, and gives insights about the possible impacts of higher energy taxes on aggregate supply and aggregate demand. Using a simple macroeconomic model of an open economy, Blanchard and Gali (2007) and Blanchard and Riggi (2013) show that the evolution of the degree of real wage rigidities and of the share of oil in production and consumption likely explain the effect of oil price shocks in the 1970s and the last decade. Therefore, recent developments in the labour market should also be considered when analysing the future response of open economies to higher energy taxes. In particular, beyond real wage rigidities, nominal wage rigidities seem to have played a role in recent low-growth patterns (Michaillat and Saez, 2015). A second strand of literature analyses the response of an open economy to structural tax reform in the aftermath of the crisis, and in particular the substitution of labour taxes for consumption taxes (Farhi et al., 2014; de Mooij and Keen, 2013). A unilateral tax reform of this type may induce a "fiscal devaluation". Increasing consumption taxes reduces the relative price of exports compared to imports because it is levied on importers and reimbursed to exporters. As a result, the reform depreciates domestic terms of trade, just as an exchange rate devaluation would do. As a consequence, domestic and foreign demand reallocates towards domestic goods, triggering an expansionary effect. However, labour tax reductions offset the general increase in consumption prices resulting from the rise in import prices. This maintains the purchasing power of domestic agents and sustains internal demand. The appeal for this policy option is clear for economies that cannot resort to exchange rate devaluations (e.g., countries of the Eurozone). Nevertheless, that literature considers the general case of consumption taxes. The specific case where fossil energy taxes are substituted for labour taxes is not treated as such. We carry out an analysis encompassing all these considerations from modern macroeconomics, public economics of taxation and energy and environmental economics.

3. Method

In this paper, we use a country-scale computable general equilibrium (CGE) model with household income groups to assess the distributive impacts of carbon pricing and the socio-economics implications of contrasted carbon tax revenue recycling schemes in France. We use a multi-sector open-economy model, IMACLIM France[6] (Ghersi and Hourcade, 2006; Ghersi et al., 2009; Le Treut, 2020). The model is used to carry out comparative statics (Samuelson, 1947) and to evaluate the impact of an exogenous carbon tax, which may lead to different emissions depending on assumptions about the functioning of the economy[7]. In the following, we describe the main mechanisms at play in the model. We give a general overview of the model in section 3.1. Section 3.2 describes the calibration data.

6 The IMACLIM-Country model family is open-access (Le Treut et al., 2019; see appendix). It provides a flexible framework to assess climate mitigation strategies and policy implications at the country level.

7 It is not used as an optimisation tool to determine the optimal policy from a cost-effectiveness point of view.

3.1. Model overview

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. Three types of agents are considered: households, a representative firm, and a public administration (plus the rest of the world). The population is composed of heterogeneous representative households who consume energy for private transportation and residential services. National production is partly purchased by domestic agents and partly exported. We assume the existence of real and nominal wage rigidities and the prevalence 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 of products (internal demand and external demand). A non-technical description of the main equations of the model are presented in the appendix, where we describe in more details the effect of tax revenue recycling options on aggregate demand and employment, and on income distribution. A complete description of the model is provided by Le Treut (2020). The appendix also provides open-source links for the code, data and simulation plan used to produce the results presented in section 4, allowing full replication.

3.2. Data

The IMACLIM-France model is calibrated on 2018 hybrid accounts describing thirty sectors, including twelve energy sectors[8]. These accounts are hybrid in the sense that they describe energy volumes that result from the harmonization of national accounts statistics (INSEE, 2018) with energy balances (EUROSTAT, 2020; Stadler et al., 2020) and energy price statistics (BP, 2020; CGDD, 2020a, 2020b, 2019; Légifrance, 2021a, 2021b). The model framework encompasses automatic subroutines for sectoral aggregation. In this analysis, we use a compact sectorial aggregation with four types of production, namely crude oil, automotive fuels, other energy for housing and a composite good aggregating all non-energy goods and services[9]. Abstracting from multi-sectoral complexities allows us to focus on the distribution of income among households and on macroeconomic mechanisms.

The central case scenario describes an economy with structural underemployment with limited wage flexibility relative to international prices. It reflects both the strong

8 Twelve energy sectors (crude oil, natural gas, coal, coke, gasoline, LPG, jet fuel, road diesel, heating oil, other fuels, electricity and heat); construction activities and real estate; seven heavy industries (mining, steel and iron, other metals, cement, chemicals, other minerals and paper); Automobiles and other transport equipment; three transport services (land, air, water); Agriculture and Forestry; Food industry; aggregate of the rest of the economy.

9 The energy mix heterogeneity of automotive fuels and the aggregate of residential energy is accounted for through agent-specific prices and CO2 contents.

competitiveness constraints specific to the French/European Union context, and the regulated nature of the French labour market. We assume an elasticity of nominal wages to the unemployment rate of -0.1, which reflects the idea that workers may not be able to negotiate higher wages in an open economy, especially in the context of an economic crisis. We use the same elasticity value as Blanchflower and Oswald (2005), although the authors used this value for the elasticity of real wages to the unemployment rate. While this scenario is seldom considered in the double dividend literature, we find it an interesting case study given the results of Blanchard and Gali (2007), Blanchard and Riggi (2013) and Michaillat and Saez, (2015). Imports and exports of non-energy products are assumed to respond to domestic and international prices, with a domestic price elasticity of exports of -0.42 (Ducoudré et al, 2019), and a domestic price elasticity of imports of +1.90 (Hertel et al, 2008). There are wide uncertainties on macroeconomic conditions, and we do not claim that these parameter values perfectly reflect the functioning of the French economy (Fontagné et al., 2018). 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 matters, for they impact the order of merit of revenue recycling options.

Households are disaggregated into ten living standard classes[10]. The disaggregation relies on the French 2011 *Budget de Famille* (hereafter BDF) survey, which covers a cross-section of 10342 households (INSEE, 2014)**Error! Bookmark not defined.**. This income and expenditure survey provides information about the structure of income sources by income group (labour, unemployment benefits, pensions, capital income, direct taxes, etc.) and about demography (number of workers, unemployed persons, pensioners, household size and composition). The dataset therefore describes inequalities by income source which impact the distributive results (see section 4.1.1). Income groups have different initial unemployment rates. The gap between the average level of unemployment benefit and the average level of wages per worker also differ according to income groups. Job creation and destruction are distributed among income groups in proportion to their initial employment rate. Prices and income elasticities of demand for both transport and home energy for each household decile are based on recent estimates for France (Douenne, 2020). Households in the top living standard decile spend on average two times more on energy than those in the bottom decile, but the share of their budget devoted to energy is 30% lower. Therefore, although higher income households consume more energy and are bound to pay more carbon tax in absolute terms, the fact that the budget share of energy is larger for lower income households means that the direct impact of a carbon tax on the income and consumption of households is regressive. The energy budget shares vary substantially within each decile. 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,

10 Here and throughout this paper, the 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).

housing type, heating mode, etc.). The energy budget shares may also vary substantially along other dimensions than income. We illustrate the importance of this horizontal inequality problem (section 4.3.3) by disaggregating the macroeconomic household account into five location classes (distinguished by density, from rural areas to the Paris area). We also use prices and income elasticities estimated for these French location classes by Douenne (2020). The carbon tax rate is calibrated so that CO2 emissions in 2018 comply with the carbon budget set by the French government (MTE, 2020). The carbon tax is thus set at ~110€/tCO2, to reduce emissions by about 19MtCO2 compared to the realised emissions in 2018.

After calibration, 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 cases (labour tax cuts vs. lump-sum transfers) and three hybrid cases combining labour tax cuts and lump-sum transfers to households to various degrees. 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[11]. We then test for contrasted assumptions on the functioning of the economy with regard to the terms of trade and the functioning of the labour market.

4. Results

We examine the impact of labour tax cuts vs. lump-sum transfers (section 4.1) and of hybrid recycling schemes (section 4.2) on the economy. We then perform a sensitivity analysis on the flexibility of wages, the terms of trade and the type of inequalities considered (section 4.3).

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 shares[12].

11 Another, more conventional way to assess the performance of policies is to compute aggregate social welfare. We do not perform such a welfare analysis, which we consider as somewhat restrictive to enlighten the debate on carbon pricing. It would indeed require making normative choices on the social welfare criterion, which may be regarded as arbitrary. One could of course explore a wide ranges of social welfare functional forms and perform an extensive sensitivity analyses on the value of normative parameters, but this is beyond the scope of this paper.

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

4.1.1. Labour tax cuts

Imposing a €110/tCO2 tax and recycling the associated revenues to cut labour taxes results in a 5.4% decrease in CO2 emissions, and leads to a 0.6% increase in GDP and a 1.2% increase in employment compared to the situation without a carbon tax (Table 1). The decoupling between CO2 emissions and GDP results not only from a change in the energy mix, but also from a structural shift towards production and goods with lower energy content. We do not explicitly model the energy mix and the structural change, but the aggregate energy coefficient in non-energy domestic production, and the reduction in fossil energy consumption by households in response to higher carbon prices. The environmental reform thus achieves a double dividend in the French context. Despite a 0.65% increase in the price of energy, the price of the composite good declines: when labour taxes are cut, the decrease in costs more than compensates the direct increase of the price of energy and the induced increase of net wages (Table 2). By blocking the spread of rising production costs, lower labour taxes maintain the competitiveness of domestic production, while raising labour intensity (+0.6%). The consecutive decrease of unemployment allows household demand to rise, which initiates a virtuous circle leading to 0.2%, 1.4% and 0.5% growth in household consumption, government expenditures, and investment[13]. The upward pressure on wages acts as a counterbalancing force. Wage increase stabilises at +0.4%. 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.

13 Triggering 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.

Table 1: Macroeconomic and distributional impacts of a €110/tCO2 tax recycled in labour tax cuts or lump-sum transfers, compared to the case without a carbon tax

		Labour tax cuts	Lump-sum transfers
Total CO2 emissions		-5.4%	-6.6%
Real gross domestic product (GDP)		+0.6%	-1.6%
Effective consumption (aggregate)		+0.2%	-1.4%
Total employment (full-time equivalent)		+1.2%	-1.2%
Real investment		+0.5%	-1.6%
Producer price of the composite good		-0.3%	+1.3%
Labour intensity of the composite good		+0.6%	+0.4%
Effective consumption[a]			
	TOTAL	+0.2%	-1.4%
	Poor (F0-10)	-0.2%	+1.5%
	Lower class (F10-30)	0.0%	-0.4%
	Middle class (F30-70)	+0.1%	-1.4%
	Upper class (F70-90)	+0.2%	-1.9%
	Rich (F90-100)	+0.5%	-2.6%
	Gini index	+0.4%	-2.8%
Share of household disposable income (point variation)			
	Poor (F0-10)	-0.00	+0.13
	Lower class (F10-30)	+0.02	+0.18
	Middle class (F30-70)	+0.02	+0.08
	Upper class (F70-90)	-0.03	-0.14
	Rich (F90-100)	-0.01	-0.25

Notes:
[a] Fisher quantity index aggregating composite consumption and energy consumption.

F# - #: fractiles of standard living (F0-10: 10% poorest households, etc.)

Sources: Authors' own calculations

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

Use of tax proceeds (€110/tCO2)	Labour tax cuts
Producer price of the composite good	-0.3%
Decreasing returns to scale and technical progress	0.0%
Energy price	+0.7%
Net wages	+0.4%
Labour taxes	-1.2%
Substitution effect	+0.2%
Other price effect	-0.2%

Sources: Authors' own calculations

However, using tax proceeds to cut labour taxes exacerbates consumption inequality. The effective consumption of the poor decreases (-0.2%, cf. Table 1), while the effective consumption of the upper class and of the rich increases (+0.5% and +0.2%, respectively), which translates into a 0.4% increase of the Gini index. The carbon tax increases inequalities because it raises the budget shares of energy expenditures of the poor substantially more than those of the rich. This simply reflects the fact that poor households, which are initially closer to their basic needs of energy services, devote a higher proportion of their income to energy. Their price-elasticities of their energy consumption (for transport and for housing) are higher than those of the rich, but they are closer to their basic needs levels (not sensitive to price).

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 (27.5% for the poor and lower income class vs. 3.9% for the upper class and the rich). While the income of the richer classes varies more with a shift from activity to unemployment, in total, the sum of the labour income and unemployment benefits varies more for the bottom decile than for the top one (+3.1% vs. +1.7%)[14]. Here the quantity effect dominates: even though the gap between wages and unemployment benefits is smaller 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, the increase of capital income (gross operating surplus), positively correlated to the living standard, benefit more the middle and upper classes[15]. Overall, the disposable income of the lower middle class is improving more than that of other income groups. This distributional pattern is accentuated by a positive correlation between activity, property income and financial assets returns. When the economy is growing, the property incomes of middle classes households groups rise sharply due to the improvement of their net positive financial positions 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. The important point here is that revenues do not adjust to GDP in a homothetic way. Given that income distribution dynamic, the lower middle classes capture a larger share of total income.

14 However, within each income group, inequalities between workers, the unemployed and pensioners are not affected by the reform schemes. Indeed, we assume that the employment benefits and pensions levels are indexed on net wages. An alternative choice of indexation, for instance on a consumption price index, would lead to additional redistributive effects and different impacts of the reform schemes on inequalities between socio-professional categories (see for instance, Goulder et al, 2019).

15 These results obviously depend on the various assumptions that affect the primary distribution of income and the secondary redistribution of incomes between households, corporations, the government and the rest-of-world (the rules adopted on the ratios of government expenditure to GDP, public investment to GDP, the indexation of social transfers, etc.).

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 (5.4% and 6.6%)[16] are achieved under opposite variations of GDP (+0.6% for labour tax cuts vs. -1.6% for lump-sum transfers), opposite variations of employment (+1.2% for labour tax cuts vs. -1.2% for lump-sum transfers) and effective consumption (+0.2% for labour cuts vs. -1.4% for lump-sum transfers).

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 0.39 points, while the cumulated share of the upper class and the rich decreases by the same amount. This leads to a significant reduction of consumption inequality, as shown by the 2.8% decrease of the Gini index, and allows the poor to increase their consumption (+1.5%). The consumption of the upper class and the rich is reduced (-2.6% and -1.9% respectively). Indeed, the average poor household pays €692 of carbon taxes but receives a lump-sum transfer of €3407—the balance amounting to 4.0% of its initial consumption budget; by contrast the average rich household pays €1469 of carbon taxes and receives a lump-sum transfer of €3456, the balance amounting to 1.0% of its budget.

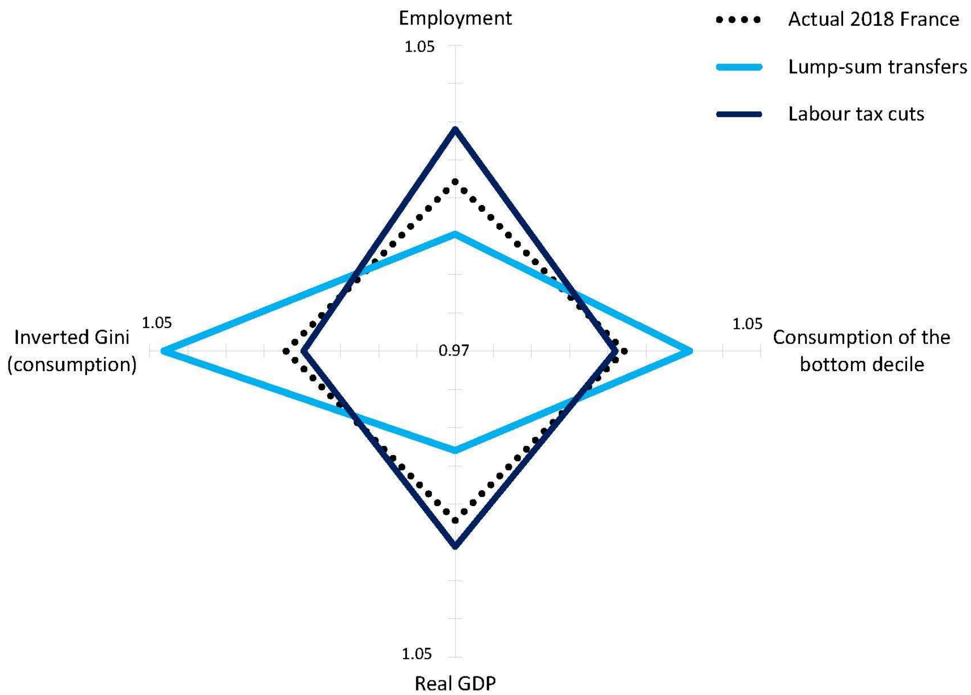
Lump-sum transfers lead to lower economic growth (-1.6%), reduced employment (-1.2%) and a contraction of investment (-1.6%). These adverse effects are mainly the result of rising production costs that spread through the economy as higher energy costs are not counterbalanced by lower labour costs. Rising 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 (-1.6%).

There is an equity-efficiency dilemma, which can be conveniently represented on a four-dimensional diagram, with two efficiency criteria (i.e., employment and real GDP) on the vertical axis, and two equity criteria (i.e., the level of consumption of the poor (first decile) and the inverse of the Gini index for the consumption of non-energy goods across households

16 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.

groups) on the horizontal axis[17]. On this diagram, the historical situation of 2018 is represented by a dashed black diamond with an index of 1 on the four criteria. Recycling a €110/tCO2 tax to cut labour taxes does not benefit equity but is far more efficient than lump-sum transfers (631,000 more jobs and 2.2 percentage points more GDP in 2018 in the case of labour tax cuts compared to lump-sum transfers). The paramount importance of the recycling scheme on the distributional impact of the reform is also duly highlighted.

Figure 1: Synthetic view of the equity and efficiency performance of labour tax cuts vs. lump-sum transfers (€110/tCO2 tax)



Comparing the net distributional effect of alternative policy options is not straightforward. Similar to most studies focusing on industrialised countries (Rausch et al., 2011, Chiroleu-Assouline and Fodha, 2014), 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

17 Note that we have not specified a particular form of private welfare function. We have only assumed that the energy consumption of each household group tends 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 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 used to finance direct compensation are recycled to cut labour taxes 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 decile[18]. This earmarks a large share of the tax proceeds for uniform 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 uniform labour tax cuts, and finances (on the remaining budget margin[19]) additional measures for the households that combine poverty and dependence on fossil fuels[20]. These measures include the accelerated provision of energy efficient equipment (building, heating, household appliances) and 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.

- In the mixed recycling option, a restricted green check option rebates to households the tax levied on their energy expenses only[21] on a fixed per-consumption-unit basis. The carbon tax levied on production is thus recycled to cut labour taxes. This mixed recycling option has the advantage of circumventing the dispute over the sharing of the tax proceeds between households and firms.

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

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

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

21 The VAT compounded on the carbon taxis also redistributed.

Table 3: Macroeconomic and distributive performance of three hybrid revenue recycling schemes (€110/tCO2 tax)

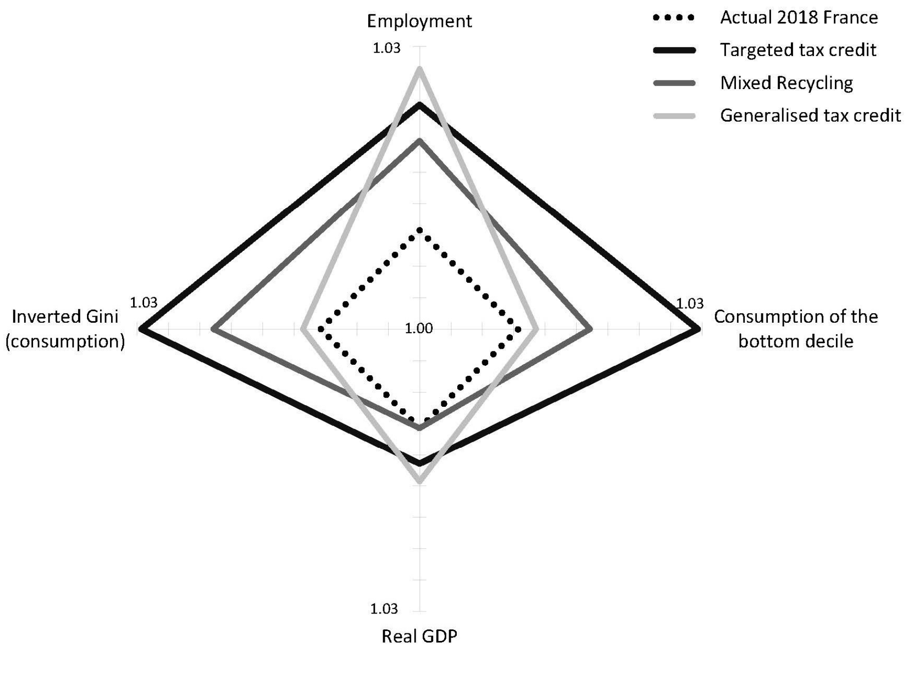
Type of direct compensation	Generalised tax credit (1)	Targeted tax credit (2)	Mixed recycling (3)
Share of tax proceeds to lump-sum transfers	15.0%	20.7%	30.4%
Producer price of the composite good	-0.1%	0.0%	+0.2%
Share of household disposable income (variation in percentage point)			
Poor (F0-10)	+0.02	+0.06	+0.04
Lower class (F10-30)	+0.04	+0.10	+0.07
Middle class (F30-70)	+0.03	+0.04	+0.04
Upper class (F70-90)	-0.05	-0.13	-0.06
Rich (F90-100)	-0.04	-0.09	-0.08

Notes: F# - #: fractiles of standard living (F0-10: 10% poorest households, etc.)

Sources: Authors' own calculations

The three proposals perform better than the historical situation on the four synthetic dimensions (Figure 2). A generalised tax credit performs significantly worse than the other two in terms of equity (consumption of the bottom decile and the inverted Gini index). This scheme however slightly outperforms the others in terms of employment and activity. 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 option, as it consumes 30.4% of the tax proceeds that are no longer available for reductions in labour taxes. The virtuous circle of growth and employment is therefore weakened. The targeted tax credit option restricts the compensation to more vulnerable households for a higher equity impact and at a lower financing cost (only 20.7% of the proceeds).

Figure 2: Synthetic view of the equity and efficiency performance of three hybrid recycling options (€110/tCO2 tax)



The targeted tax credit and measures option favours the poor and lower classes, which are more vulnerable to the carbon tax in the other two options (their shares in household disposable income rises by 0.06 and 0.10 points)[22]. 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.). Lump-sum transfers can be differentiated according to important horizontal inequality dimensions, while it may be more difficult to differentiate the labour tax system and implement non-uniform tax cuts, as considered by Chiroleu-Assouline and Fodha (2014). 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. 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 how the evaluation depend on the type of equity considered (vertical vs. horizontal). In the results presented above (thereafter called the central case), we assumed an elasticity of nominal wages to the unemployment rate of -0.1, a domestic price elasticity of exports of -0.42 and a domestic price elasticity of imports of +1.90, and a balanced government budget (i.e., no further debt creation). The results of the sensitivity analysis are summarised in Table 5. The hybrid case refers to the target tax credit option.

4.3.1. 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 nominal wages to the unemployment rate is set at -0.1. Here we examine the polar case of fully flexible wages. We assume an unchanged constraint on the government budget balance and unchanged terms of trade compared to the central case (cf. above).

22 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 decile, but a much smaller benefit from employment gains.

Table 5: Sensitivity analysis – Summary of results (change wrt actual 2018 France)

Trade: central case	-0.1 elasticity of wages (central case)			Fully flexible wages		
	labour tax cuts	lump-sum	hybrid	labour tax cuts	lump-sum	hybrid
Employment	+1.2%	-1.2%	+0.7%	+0.0%	+0.0%	+0.0%
Real GDP	+0.6%	-1.6%	+0.2%	-0.5%	-0.5%	-0.5%
Gini index	+0.4%	-2.8%	-1.0%	+0.6%	-2.9%	+0.7%
Consumption of the poorest 10%	-0.2%	+1.5%	+1.0%	-1.0%	+2.4%	-1.5%
	(a)			(b)		

Trade: relatively open economy	-0.1 elasticity of wages (central case)			Fully flexible wages		
	labour tax cuts	lump-sum	hybrid	labour tax cuts	lump-sum	hybrid
Employment	+1.3%	-2.1%	+0.7%	+0.0%	+0.0%	+0.0%
Real GDP	+0.7%	-2.4%	+0.2%	-0.5%	-0.5%	-0.5%
Gini index	+0.4%	-2.7%	-1.0%	+0.6%	-2.9%	+0.7%
Consumption of the poorest 10%	+0.0%	+0.6%	+0.9%	-1.1%	+2.3%	-1.5%
	(c)			(d)		

Trade: relatively closed economy	-0.1 elasticity of wages (central case)			Fully flexible wages		
	labour tax cuts	lump-sum	hybrid	labour tax cuts	lump-sum	hybrid
Employment	+1.0%	-0.2%	+0.8%	+0.0%	+0.0%	+0.0%
Real GDP	+0.5%	-0.6%	+0.2%	-0.4%	-0.4%	-0.4%
Gini index	+0.4%	-2.9%	-1.1%	+0.5%	-2.9%	+0.7%
Consumption of the poorest 10%	-0.3%	+2.5%	+1.1%	-0.8%	+2.6%	-1.3%
	(e)			(f)		

Sources: Authors' own calculations

When wages are fully flexible (Table 5b), all recycling strategies have identical 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). The option of hybrid recycling is no longer attractive since lump-sum transfers redistribute income at no cost. Hybrid recycling has identical effects than lump-sum transfers on employment and GDP, but is inferior on inequality and poverty. As the modern macroeconomic literature shows, wage rigidities exist in most policy contexts, therefore there is a compromise to find between equity and efficiency. This sensitivity test illustrates the importance of the labour market assumptions for the evaluation and the selection of the best policy design. Further research is needed to analyse how the evaluation is sensitive, and the efficient-cum-equitable recycling strategies robust, to various labour market configurations and uncertainties.

4.3.2. The influence of the terms of trade on equity

When there are wage rigidities, the revenue recycling strategies considered have contrasted consequences on production costs. Lower (or higher) production costs affect the trade balance and GDP[23]. The order of magnitude of this effect depends on assumptions on the relative price elasticity of exports and imports and on the way the constraint on public debt is implemented.

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 5c). 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 5c), in particular regarding the consumption of the poorest decile. 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 5e), 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 note the cross effects of assumptions on wage rigidities and on the terms of trade. Compared to our central assumption with wage rigidities (an elasticity of net wages to the level of unemployment of -0.1), the assumption on the terms of trade have no effect on macroeconomic indicators when wages are fully flexible (Table 5b, 5d and 5f). In any case, net wages adjust to maintain the same level of aggregate demand. Greater wage

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

moderation occurs in a relatively open economy, i.e., an economy that is more exposed to international price competition. We observe similar results along the distributive dimensions.

When lifting the constraint of a balanced public budget (i.e., allowing for public debt, cf. Table 6b), labour tax cuts still perform better than uniform lump-sum transfers in terms of GDP and employment, and lump-sum transfers still perform better than labour tax cuts in terms of redistribution. However, the differences on efficiency indicators are smaller, while they are greater on equity indicators. The labour tax cuts option expands the tax base and reduces the debt-to-GDP ratio, while the lump-sum transfers option increases public debt[24]. In order to restore the public debt-to-GDP ratio (Table 6a), additional reductions in labour taxes are allowed in the labour tax cuts option, while labour taxes must increase to meet the public debt constraint in the lump-sum transfers option. Thus, under the constraint of a balanced public budget, wages increase more in the labour tax cuts option than in the lump-sum transfers option, which explains the larger differences on equity indicators. We obtain exactly the same results with the hybrid option, because this policy scheme uses the additional tax revenues generated by GDP gains to finance an increase in social transfers.

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

	Constrained public deficits (central case)			No constraint on public deficits		
Trade: central case Wages: central case	labour tax cuts	lump-sum	hybrid	labour tax cuts	lump-sum	hybrid
Employment	+1.2%	-1.2%	+0.7%	+0.8%	-0.5%	+0.7%
Real GDP	+0.6%	-1.6%	+0.2%	+0.2%	-0.8%	+0.2%
Gini index	+0.4%	-2.8%	-1.0%	+0.5%	-2.8%	-1.0%
Consumption of the poorest 10%	-0.2%	+1.5%	+1.0%	-0.8%	+2.4%	+1.0%
Debt/GDP	+0.0%	+0.0%	+0.0%	-1.8%	2.5%	+0.0%
		(a)			(b)	

Note: Results obtained for the hybrid revenue recycling scheme are identical in (a) and (b). Indeed, the budgetary cost of the increase in social transfers exactly offsets the budgetary surplus generated by the fiscal substitution.

Some general results emerge from the sensitivity analysis. First, lump-sum transfers are unequivocally superior to labour tax cuts (and to hybrid recycling options) only when wages are fully flexible. 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. In that case, there is no trade-off between equity and efficiency. Lump-sum transfers have no cost in terms of economic activity and employment, and they can be widely used to offset the distributional impacts of the carbon price. Second, when there are wage rigidities, labour tax cuts are superior to lump-sum transfers in terms of employment

24 In this paper, we assume that the country's borrowing capacity is unconstrained and we do not represent nonlinear adjustments in interest rates in response to growing macroeconomic imbalances. This corresponds to an environment where the country can roll over its debt. Different assumptions about the macroeconomic effect of different debt-to-GDP ratios would presumably affect the results. Bringing the analysis closer to modern monetary and financial analysis in an open economy is an avenue for further research.

and GDP because production costs do not increase. The gap in terms of GDP and employment between both options increases with the degree of international price competition and the constraint on public dept. In those cases, the trade-off between equity and efficiency depends on the specific policy context. It depends not only on normative parameters (the priority given to distributive or macroeconomic indicators), but also on a combination of positive parameters (the contextual assumptions made about the labour market, external trade and public debt[25]).

4.3.3. 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 (Berry, 2019; Douenne, 2020; 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 ten income groups, we now consider the case where households are aggregated into five 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.

Table 7: Sensitivity analysis – Impact of the type of distribution considered on policy performance

	Vertical equity (20 income groups)		
Trade and wages: central case	labour tax cuts	lump-sum	hybrid
Employment	+1.2%	-1.2%	+0.7%
Real GDP	+0.6%	-1.6%	+0.2%
Gini index	+0.4%	-2.8%	-1.0%
Consumption of the poorest 10%	-0.2%	+1.5%	+1.0%

(a)

	Horizontal equity (5 location groups)		
	labour tax cuts	lump-sum	Hybrid
Employment	+1.2%	-1.2%	+0.7%
Real GDP	+0.6%	-1.5%	+0.1%
Gini index	+5.9%	+1.4%	+5.0%
Consumption of rural households	-0.5%	-1.7%	-0.8%

(b)

The results show very similar results in terms of employment and GDP (comparing Tables 7a and 7b, row by row)[26]. 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 4.6% and 9.5%) than according to income (between 5.4% and 8.4%,

25 Fodha et al (2018) show that an environmental tax reform that allows for a decrease in the debt-output ratio could lead to good macroeconomic performance. However, less tax revenue would be available in the short run to compensate for intra-generational distributional impacts. Further analysis is needed to study the sensitivity of the equity-efficiency trade-off under different public deficit constraints.

26 This 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.

cf. Table 8). Furthermore, urban areas benefit more from an increase in economic activity. Rural areas are less sensitive because their ex ante unemployment rate is lower than those of more densely populated areas (6.7% compared to 8.9% in the greater Paris region and 9.3% to 12.0% in other urban areas). The gap between wages and unemployment benefits also increases with density (+64% in rural areas to +148% in the greater Paris region).

In the case of horizontal equity, both lump-sum and hybrid recycling increase inequalities (higher Gini index and lower consumption of rural households). 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 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.

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

Degree of urbanization	Share of budget to energy expenditures
Rural	9.5%
Urban (< 20 000 inhabitants)	8.3%
Urban (20 000 to 100 000 inhabitants)	7.3%
Urban (> 100 000 inhabitants)	6.4%
Greater Paris region	4.6%

(a)

Income group	Share of budget to energy expenditures
Poor (F0-10)	8.4%
Lower class (F10-30)	8.4%
Middle class (F40-70)	7.6%
Upper class (F70-90)	6.5%
Rich (F90-100)	5.4%

(b)

5. Conclusion

This paper examines the macroeconomic and distributive consequences of a carbon pricing reform. The contributions are twofold. On the one hand, we propose an 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 existence 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 assumptions made about nominal and real rigidities in the labour market. There is indeed an opportunity cost of devoting too large a share of carbon tax revenues to direct lump-sum redistribution to households, and this opportunity cost depends on the country-specific macroeconomic context. Therefore, from a public economics point of view, arguments pertaining to the acceptability of a reform, which are used to build a case in favour of lump-sum transfers, should therefore be somewhat balanced. For instance, the "carbon dividends" proposals, where all the tax revenue are redistributed lump sum and uniformly, appear costly. In other words, large lump-sum transfers, which may be perceived as equitable in the short-term, could have long-term consequences through either higher prices, lower income or fewer jobs. 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 national (macroeconomic and distributional) contexts. Inequalities across various economic sectors - and the design of compensating measures for energy-intensive industries - should also inter the picture, as equity and competitiveness arguments combine to oppose ambitious climate policies. Beyond the carbon tax and the use of its revenue, research is also needed to examine broader comprehensive policy packages, combining price and non-price instruments, public finance and private finance reforms. Accounting for larger sets of policy instruments within comprehensive frameworks would indeed help analysing trade-offs between competing goals and finding compromises. 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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APPENDIX – MODEL EQUATIONS

This section presents a non-technical description of the main equations of the model. It also provides intuition of the effect triggered by the carbon tax and the revenue recycling options on aggregate demand and employment, as well as on income distribution.

A description of the formalisation of the system of equations is available at the following link: http://www.centre-cired.fr/wp-content/uploads/2020/09/cired_wp_2020_85_le_treut.pdf
The IMACLIM model platform provide all codes and data in open-source: https://zenodo.org/record/3403961#.YDp6l2hKhaR

The code, data and simulation plan used to produce the results of this article are available in open-source:

- **Calibration data**

  https://github.com/GaelleLeTreut/IMACLIM-Country/tree/PaperEquityEfficiency/data/data_FRA2018

  "Data_RoW" (Rest-of-the world) is not used in this study. The "H10" folder contains data used to disaggregate the Households macroeconomic account into ten representative Households accounts (ten income groups, deciles). The "L5" folder contains data used to disaggregate this account into five location groups (by density, see sensitivity analysis, section 4.3.3). DataAccountTable.csv provides data for the macroeconomic accounts of representative institutional agents (Corporations, Government, Households, Rest-Of-the-World). IOT_Val.csv, IOT_Qtities.csv, IOT_Prices.csv, and IOT_CO2Emis.csv provide the Input-Output data in respectively monetary units (k€2018), real units (ktoe, ton oil equivalent, for energy; k€2018 for non-energy products), CO2 emissions unit (MtCO2), and prices (€2018/real unit). Demography.csv and Labour.csv contains demography figures and the full time equivalent workers working in each economic sector. Files beginning by "Index_" attribute data to model parameters and variables.

- **Parameters**

https://github.com/GaelleLeTreut/IMACLIM-Country/tree/PaperEquityEfficiency/params/params_FRA2018/AGG_4SecB

Files that end with "_H10.csv" and "_L5.csv" contains the exogenous parameters used when the model represent respectively ten income deciles and five location groups. sigma_pC, sigma_ConsoBudget, ConstrainedShare_C provides data for price-elasticities of energy used for transport and for housing, budget elasticities, and the share of initial energy consumption which is constrained in the medium term (basic needs). params_sect_AGG_4SecB.csv gives the wage-curve elasticity, the constrained share of labour and capital in production in the medium term, the factor-price elasticity of substitution, the elasticities of exports and imports to the term of trade.
This set of parameters is used by default in our study. However, the simulation plan (see below) modify some default parameters and some default equations in the system in order to produce the main text results (central case and sensitivity analysis simulations).

- **System of equations**

The default set of equations used to produce the "central case" simulation of a carbon and labour taxes cuts is listed in the following file:

https://github.com/GaelleLeTreut/IMACLIM-Country/blob/PaperEquityEfficiency/code/Systeme_Resolution/SystemOpt_Static_temp.csv

The corresponding functions (equations) are available in the functions library:

https://github.com/GaelleLeTreut/IMACLIM-Country/tree/PaperEquityEfficiency/library

The Economic_equations.sci provides an library of economic equations. This library contains both the default equations and the alternative equations. The latter are called by the simulation plans code to produce the alternative policy results and sensitivity results.

- **Simulation plan**

  https://github.com/GaelleLeTreut/IMACLIM-Country/blob/PaperEquityEfficiency/study_frames/study_frames_FRA2018/Simulations/SimuEquityEfficiency.csv

  The simulation plan SimuEquityEfficiency.csv allow to reproduce all the results.

The following presents a non-technical description of the main equations of the model and gives intuitions for the macroeconomic and distributive results.

A.1 Aggregate demand and employment

a) Aggregate demand

Aggregate demand (Y) depends on both 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 (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:

$$Y = C\,[C_E, p_E, p, \Phi\,[w, p, Y, \alpha]] + (X\text{-}M)\,[p]$$

with partial derivatives, $C'C_E<0$, $C'p_E<0$, $C'p<0$, $C'\,\Phi>0$, $(X\text{-}M)'p<p$

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 final energy consumption (C_E) is rather inelastic 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 households consume more energy in absolute terms, a uniform redistribution of the tax will benefit the poorest. If the latter devote a larger share of their income to current expenditures, internal demand may increase. However, for matters of incentive efficiency, energy taxation should 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). Direct lump-sum compensation of households may therefore 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 markets[27]. The price-setting function (pricing rule) takes the following form:

$$p = \mu * MC\ [p_E, p, p_L, e, ci, l]$$

with partial derivatives, $MC'p_E>0$, $MC'p>0$, $MC'p_L>0$, $\$MC'e>0$, $MC'ci>0$, $MC'l>0$

A carbon tax increases production costs if profit margins are fixed and if the economy cannot substitute away from fossil energy and cannot produce the same level (Y) of non-energy goods and services without additional costs. In this case, a carbon tax induces a general price inflation, reducing aggregate demand.

Let us now consider the effect of revenue recycling schemes on demand. Reducing labour taxes may contribute to mitigate the carbon- tax-induced general price inflation by lowering labour costs (p_L). Labour intensive industries would benefit from this tax shift while carbon intensive industries would not. As a whole, labour costs being widely distributed among industries, the general cost increase due to the carbon tax would 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 budget[28] Φ.

b) Employment and wages

27 Assumptions 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)

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

Let us now consider the effect of revenue recycling schemes on employment and wages. In the literature, the effect of the tax shift described above on employment 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 market[29]. For our analysis, it is sufficient to assume that wages respond negatively to the level of unemployment (as tensions 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 price 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 heterogeneous households. Here, we assume that for a given set of prices, the share of energy expenditures decreases with the budget[30] Φ, because final energy services include some basic needs. As a whole, the wage setting function takes the following form:

$$w/CPI[p_E, p, \Phi]^{\gamma} = u\,[Y, l]^{-\lambda}$$

with partial derivatives, $CPI'p_E>0$, $CPI'p>0$, $u'Y<0$, $u'l<0$

Parameters λ and γ 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) are a function of the labour tax (t_L) and of net nominal wages (w).

$$p = \mu * MC\,[\,p_E, p, p_L\,[t_L, w], e, ci, l\,]$$
$$= \mu * MC\,[\,p_E, p, p_L\,[t_L, w[p_E, p, \Phi, Y, l]\,], e, ci, l\,]$$

with partial derivatives, $MC'p_E>0$, $MC'p>0$, $MC't_L>0$, $MC'Y>0$, $MC'e>0$, $MC'ci>0$, $MC'l>0$

29 In 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 arrangements and social norms that evolve over time.

30 At least in the case of a uniform increase of budget across households. This cannot be the case, however, in the case of larger inequalities, for instance if the budget increase is concentrated towards the richest households, while the poorest households experience contractions of their budget instead.

When taking into account the response of wages, the ultimate effect of recycling tax revenues towards labour 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 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 cost reductions from lower labour taxes[31]. 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.

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 demand[32].

A.2 Income distribution

Let us now consider the effect of a carbon tax on the purchasing power of households. Each household uses a proportion (c_h) of its income (I_h) to consume both energy and non-energy products ($C_{E,h}$, $C_{NE,h}$). The purchasing power of households for non-energy goods (C_h) depends on disposable income (I_h), on the aggregate price of non-energy goods (p) and on energy expenditures ($p_E * C_{E,h}$). It is given by the following expression:

$$C_h = 1/p * (\Phi [I_h, c_h]-p_E * C_{E,h})$$

$$\text{with } \Phi [I_h, c_h] = c_h * I_h$$

The capacity of households to reduce their energy consumption $C_{E,h}$ in response to higher energy prices depends on their substitution possibilities and energy needs. Lower income groups have a larger share of their budget devoted to energy consumption, and their energy consumption is closer to basic energy needs. The closer to their basic energy needs, the smaller the ability of households to alleviate their tax burden by reducing their energy consumption. Information on this matter is very limited, as household groups considered here combine very heterogeneous situations in terms of geographical locations, heating, cooking and electric equipment, private vehicle ownership, etc. As a consequence, higher energy prices tend to increase consumption inequalities. However, the net distributional outcome depends on the recycling strategy and on overall income redistribution.

31 However, 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.

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

Let us now consider the distributive effects of tax revenue recycling options. The tax revenue recycling option impacts disposable income I_h: indirectly so through its effect on aggregate employment, and directly so in the case of lump-sum transfers, which add to already existing social transfers. Households' disposable income (I_h) depends on income tax (T_h), social transfers (B_h), and labour income (I_L). The tax revenue recycling option affects the aggregate level of employment, and aggregate employment variations are distributed among classes according to their specific unemployment and payroll tax rates[33]. We assume homothetic variations of jobs (groups with higher initial unemployment experience larger job variations). As a consequence, changes in unemployment affect the poorest households more. The way labour income is distributed among households depends on the wage differentials (w_h) and on the distribution of jobs (L_h).

Both labour tax cuts and lump-sum transfers impact consumption inequalities. Labour tax cuts indirectly feed the budget of the poorest households, as those benefit the most from higher employment, while lump-sum transfers directly increase disposable income by adding to already existing social transfers.

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 consumption[34]; (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

33 In addition, the income shift induced by the transition from unemployment to activity or activity to unemployment is specific to each class.

34 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 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:

$$I_h = (1 - T_h) * (I_{L,h} [w_h, L_h] + I_{K,h} [I_h-E_h] + V_{i,h} + B_{i,h} [L_h, CPI, w])$$

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. 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.

$$I_h-E_h = (1-c_h-g_h) * I_h$$

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:

$$C_h = 1/p * (\Phi [I_h, c_h]-p_E * C_E)$$

$$\text{with} \qquad \Phi [I_h, c_h] = c_h * I_h$$

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 * 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.