Social-environmental-economic trade-offs associated with carbon-tax revenue recycling

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Abstract

As carbon taxes gain traction and grow tighter in OECD countries, the question of their recycling becomes crucial for political acceptance. Considering the impact of the French carbon tax in the residential sector, we examine the trade-offs between fuel poverty alleviation, energy savings and economic leverage for two revenue-recycling options – as a lump-sum payment or as a subsidy for energy efficiency improvement, each restricted to low-income households – defined as those belonging to the first two quantiles of the income distribution. We do so using Res-IRF, a highly detailed energy-economy model that interacts housing features (single vs. multi-family, energy efficiency, heating fuel) with key household characteristics (tenancy status, income of both owners and occupants). We find that the energy efficiency subsidy recycling is superior to the lump-sum payment in all respects; it even fully offsets the regressive effect of the carbon tax from 2025 onwards. No recycling, however, effectively addresses fuel poverty in private, rented housing.

Keywords: carbon tax, revenue-recycling, building sector, fuel poverty, energy efficiency subsidies

JEL codes: D63, H23, Q47

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Introduction

Carbon taxes are increasingly adopted in OECD countries, typically with pre-determined, growing rate schedules. After several unsuccessful attempts to put a price on carbon in the past three decades, the French Government levied in 2014 a 7€ tax per ton of CO_2 on fossil-fuel end-use, scheduled to grow to 56€ in 2020 and 100€ in 2030. Tax revenues have so far been allocated to the general Sate budget. While the policy went at first virtually unnoticed, concerns over its distributional impacts have recently ignited social unrest.[1]

The question of how to reallocate carbon-tax receipts within the economy in a socially fair and economically efficient manner is not new (e.g., Parry, 1995), yet still unresolved (Klenert et al., 2018). It is all the more sensitive since the Paris Agreement, which entitles countries to make carbon emission reduction commitments. This adds an environmental constraint to the tensions between budgetary and social concerns that are inherent in any form of taxation. The distributional impacts of carbon taxes have mostly been studied across sectors (Hamilton and Cameroun, 1994; Goulder, 1995; Metcalf, 2009) and within the household sector (Speck, 2009; Callan et al., 2009; Rausch et al., 2011; Liang and Wei, 2012) in general equilibrium frameworks. Micro-simulation studies have recently focused in great detail on household transportation and housing expenditures and examined a multitude of revenue recycling options among households of differing income (Berry, 2019; Douenne, 2018).

In this paper, we focus on the distributional impact of the carbon tax on a specific fraction of household consumption – energy expenditure for space heating – which we are able to model with a high level of detail. This allows us to examine subsidies for energy efficiency improvements as a previously unstudied recycling option. We do so using Res-IRF (Giraudet et al., 2012), an energy-economy model interacting housing features (single vs. multi-family, energy efficiency, heating fuel) with key household characteristics (tenancy status, income of both owners and occupants). Two thirds of the French carbon tax is levied on households, equally divided between housing and transportation. This means that energy use for space heating covers approximately one third of the fiscal base of the tax. This fraction is central in public debates. Our analysis allows us to formulate recommendations as to how to better balance the budget of public taxes and subsidies in the field of home energy renovation.

The paper is organized as follows. First, we provide an overview of the modelling framework. Second, we introduce the policy scenarios considered. Third, we discuss the fuel poverty indicators used in the evaluation. Fourth, we compare the social-environmental-economic trade-offs under the different scenarios. Fifth, we discuss the results and some avenues for further research.

Modelling framework

Res-IRF is a model of residential demand for space heating in France. It integrates detailed descriptions of the energy performance of the building stock and of household behaviour (Giraudet et al., 2012). Res-IRF has been developed to contribute to improving behavioural realism in integrated models of energy demand (Mundaca et al., 2010; McCollum et al., 2017). To this end, it incorporates a number of barriers at the source of the so-called 'energy-efficiency gap' – the discrepancy between actual energy use and thatpredicted by engineering studies (Jaffe and Stavins, 1994; Gillingham et al., 2009). These include the rebound effect, landlord-tenant dilemma, barriers to community decision-making in multi-family housing, non-energy attributes of renovations (e.g., acoustic, aesthetic) and credit constraints.

Segmentation of the building stock

The dwelling stock is parameterized with the Phébus survey[2] that links the socio-economic characteristics of households and the energy efficiency of the dwellings they inhabit. The dwellings

[1] For a brief account, see for instance 'Wanted : A fair carbon tax,' Editorial, *Nature*, 13 December 2018.

[2] http://www.statistiques.developpement-durable.gouv.fr/sources-methodes/enquete-nomenclature/1541/0/enquete-performance-lhabitat-equipements-besoins-usages.html

considered are main residences in continental France, which contain 23.9 million dwellings. The dwelling stock is segmented in 1,080 categories, split as follows:

- Nine categories of energy performance, corresponding to labels A to G of the French energy performance certificate (EPC) in dwellings built before 2012, and labels ‘low energy’ and ‘net zero energy’ in dwellings built after 2012. These categories summarize the technical characteristics of the envelope and the heating system.
- Four fuels used as the primary source for space heating: electricity,[3] natural gas, fuel oil and fuel wood (altogether covering 91% of energy demand for space heating).
- Two categories of housing: single- and multi-family units, respectively weighing 61% and 39%.
- Three categories of property owners: owner-occupiers, landlords of rented dwellings, and social-housing organizations, respectively weighing 61%, 24% and 15% of dwellings.
- Five levels of income for both owners and occupants, closely aligned with the income quintiles of the French population given by INSEE.

Renovation decisions

The equations of the model are fully detailed in Giraudet et al. (2012). In a nutshell, renovation decisions are made by homeowners – owner-occupiers, landlords and social housing providers. For a dwelling labelled I before retrofit, they proceed along two margins:

- Intensive margin: selection of one post-retrofit efficiency label f among labels {i+1,…,A}. The market share of each post-retrofit label is determined by a discrete-choice function based on the life-cycle cost of each option, including investment costs and lifetime discounted operating costs. It is however more detailed in four respects. First, heterogeneous credit constraints are captured by discount rates decreasing with income. Second, frictions inherent in community decision-making are captured by higher discount rates in multi-family units, as compared to those applied to single-family units (cf. Table 1). Third, under-capitalization of energy savings in rental housing are captured by a short investment horizon of three years – the typical duration of a lease contract –as opposed to 30 years in owner-occupied dwellings and social housing. Fourth, intangible costs are calibrated by confronting the model to observed upgrade patterns; they capture, for instance, the inconvenience caused by renovation works and peer effects.
- Extensive margin: the decision-maker decides whether or not to upgrade a dwelling of label i to a higher label f>i. This decision depends on the net present value of an average renovation project, measured as the life-cycle cost difference between the status quo and the different upgrade options weighted by their market share. The correspondence between net present value and renovation numbers follows a logistic function capturing heterogeneity in heating preference and habits. It is calibrated against a renovation rate of 3% of existing dwellings in 2012, based on ADEME (2016).

Table 1. Discount rates

Income category	Single-family housing	Multi-family housing	Social housing
C1 (lowest income)	15%	37%	4%
C2	10%	25%	4%
C3	7%	15%	4%
C4	5%	7%	4%
C5 (highest income)	4%	5%	4%
Weighted average	**8%**	**17%**	**4%**

[3] Implicitly, electricity is used for electric heating up to dwellings labelled C and heat pumps for higher labels.

Life-cycle cost calculations rely on renovation cost data that are inherently difficult to obtain. Indeed, our representation of energy efficiency improvements through EPC label upgrades, rather than explicit measures on the envelope and the heating system, requires some data post-treatment that is not readily available. We therefore create a cost matrix in which part of the data is based on observations while the remaining is interpolated according to two standard economic rules: the marginal cost of energy efficiency is increasing; economies of scale make it cheaper to perform a given upgrade at once rather than sequentially. The resulting matrix has an average cost of 0.08 euros per lifetime discounted kilowatt-hour saved (Table 2).

Table 2. Renovation costs (€/m²)

		Post-retrofit label (f)					
		F	**E**	**D**	**C**	**B**	**A**
Pre-retrofit label (i)	**G**	76	136	201	271	351	442
	F		63	130	204	287	382
	E			70	146	232	331
	D				79	169	271
	C					93	199
	B						110

Heating behaviour

The intensity with which occupants – owner-occupiers and tenants – heat their dwelling is defined as the ratio between realized energy use, as disclosed in energy bills, and that predicted by the EPC label. It is determined endogenously by three variables: the price of energy, the energy efficiency of the dwelling, as measured by its EPC label, and the income of the occupying household. This is modelled through an iso-elastic, negative relationship between heating intensity and the household's income share dedicated to heating, parameterized with empirical estimates from Cayla and Osso (2013). While the previous version of the model did not factor in income in this relationship, the combination of information on a dwelling's energy efficiency and its occupants' income provided by the Phébus survey made this improvement possible. Note that an increase in heating intensity in response to efficiency improvements is interpreted in the model as a comfort gains, due to either behavioural (e.g., rebound effects) or physical change.

Policy scenarios

Reference scenario

In the reference scenario, as in other scenarios, the model is fed by three exogenous inputs: population, total income, and energy prices. In the analysis presented here, population grows at 0.3% p.a. and household income grows uniformly at 1.2% p.a. Energy prices grow (in real terms) according to a scenario borrowed from French authorities at 1.4% p.a. for natural gas, 2.2% for fuel oil, 1.1% for electricity and 1.2% for fuel wood. This is equivalent to an energy price index growing at 1.5% p.a. in the reference scenario.

The reference scenario is referred to as 'NT' for 'no tax.'

Carbon tax

The carbon tax has been implemented in France since 2014 with the schedule enacted by the French law of 2014 (Table 2). It is applied in the model to fuel oil and natural gas (electricity is not subject to the carbon tax in France), with respective carbon contents of 271 and 206 gCO_2/kWh. The latter decreases from 2020 onwards at 1% p.a. to take into account decarbonisation targets set by the Government, supposed to be met by biomass. The carbon tax is subject to a 20% VAT.

Table 2. Time profile of the carbon tax (per ton of CO_2, in real terms)

2014	2015	2016	2017	2018	2019	2020	2020-30	2030-50
7€	14.5€	22€	30.5€	39€	47.5€	56€	+6% p.a., 100€ in 2030	+4% p.a.

The carbon tax is, just like the price of energy, myopically expected; that is, households make their investment decisions based on the contemporaneous price of energy, carbon tax included. The carbon tax increases operating costs. It therefore affects both renovation decisions (by changing the relative life-cycle costs of renovation options) and the intensity of utilization.

In the ‘UR’ scenario, the revenue from the carbon tax is ‘unrecycled’ to households.

Lump-sum recycling

In the first recycling scenario, labelled ‘LS,’ the total revenues of the carbon tax are rebated in a lump-sum manner to households from the first two quintiles of the income distribution. The individual allowance is calculated each year by dividing the total revenue collected the previous year by the number of targeted households that year. The lump-sum payment increases income; it therefore does not affect renovation decisions but does affect the intensity of utilization.

Recycling as an energy-efficiency subsidy

In the second recycling scenario, labelled ‘SU,’ total revenues are recycled as a subsidy for energy renovations to homeowners from the first two quintiles of the income distribution (who account for 10% of the population of homeowners in France). The subsidy is proportional to the kilowatthours saved. In that regard, it resembles the subsidies offered by energy suppliers in France to comply with their energy saving obligations (Giraudet et al., 2012b). We determine the subsidy rate (in Euros per kilowatthour saved) each year as the solution that equates total carbon-tax revenues (in Euros) and the energy savings achieved by the subsidies. This is computed through an iterative process. The subsidy lowers investment costs, thereby affecting renovation decisions.

Fuel poverty indicators

We consider the three indicators proposed by the French *Observatoire national de la précarité énergétique* (ONPE, 2016): the energy-to-income ratio; the low-income, high cost, index; the intensity of utilization of the heating system. While the first two are routinely used in other countries, the third is more specific to France. Note that, while renovation may increase property value, hence household wealth (either through rents or resale value), we do not account for this effect for lack of reliable estimates.

Energy-to-income ratio (EIR)

The EIR is the most common indicator of fuel poverty. Here we measure it by collecting those households that allocate more than 10% of their income to energy expenditures for heating purposes. Importantly, we consider conventional, rather than actual, energy consumption in order not to miss fuel-poor households that restrict their heating behaviour and therefore incur relatively low heating bills while suffering from heating discomfort. While the indicator is restricted to the first three deciles of the income distribution by the ONPE, our lower granularity leads us to restrict it to the first two quintiles.

Low-income, high cost index (LIHC)

The LIHC has been more recently proposed by Hills (2012) to overcome the alleged limitations of the EIR, in particular that it may include some wealthy households in times of high energy prices and miss truly fuel-poor households in times of low energy prices. The LIHC alternative is now the official indicator in the UK (Robinson et al., 2018). Here we measure it by collecting those households whose (i) income, net of energy expenditures, falls below 60% of the median net income and (ii) heating expenditures exceed the median. We compute it by square meter (m^2), as is done by the ONPE.

Intensity of utilization of the heating system (IU)

The ONPE uses stated thermal comfort as an additional measure of fuel poverty. The indicator gathers households who subjectively state at least one of the following: inefficient heating system; heating breakdown; poor insulation; heating restriction; energy disconnection. We approximate this indicator with the intensity of utilization, i.e., the ratio between actual and conventional energy use parameterized after Cayla and Osso (2013). We determine an IU threshold so that the number of households that fall below matches that estimated by the ONPE, adjusted to our slightly smaller perimeter.

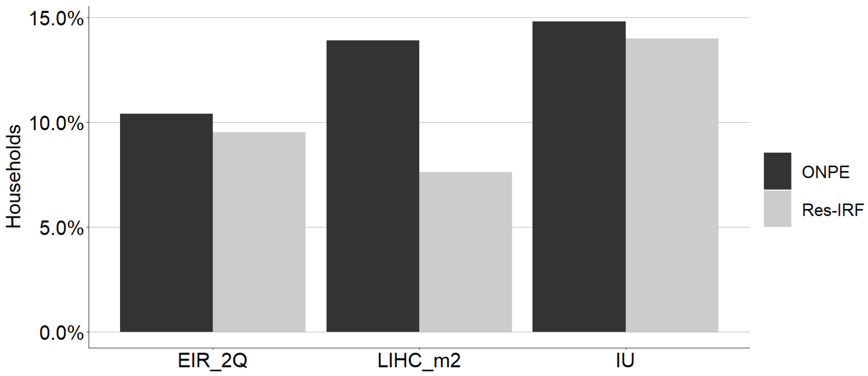

Figure 1. Share of total households (24 millions) under the different indicators

Figure 1 compares our estimate for the base year (2012) to that obtained by the ONPE with different data. Both estimates are remarkably close for the EIR and IU estimates – the latter by construction. In contrast, we significantly under-estimate the number of LIHC households. The discrepancy can be explained by differences in the two datasets and biases due to our use of quintiles whereas the indicator is based on medians.

Trade-offs between revenue-recycling options

Social outcome

Figure 2 shows how the different indicators evolve over time without ('NT') and with ('UR') the unrecycled carbon tax. The left panel shows that both the EIR and the IU decline consistently, which can be attributed to autonomous energy efficiency improvement due to rising energy prices and the natural stock turn-over subject to building codes. The numbers are systematically higher for these two indicators on the right panel, which indicates that the carbon tax retards autonomous fuel poverty alleviation. This is a new, previously undocumented manifestation of the general notion that the carbon tax is – at least before revenue recycling – socially regressive.

In contrast to the other two indicators, the LIHC remains stable regardless of the carbon tax, which reminds us that, in considering distributions rather than absolute criteria, this indicator is primarily one of fuel inequality rather that fuel poverty. For this reason, combined with the fact that our estimate of this indicator is biased, we ignore it in the remaining of the paper.

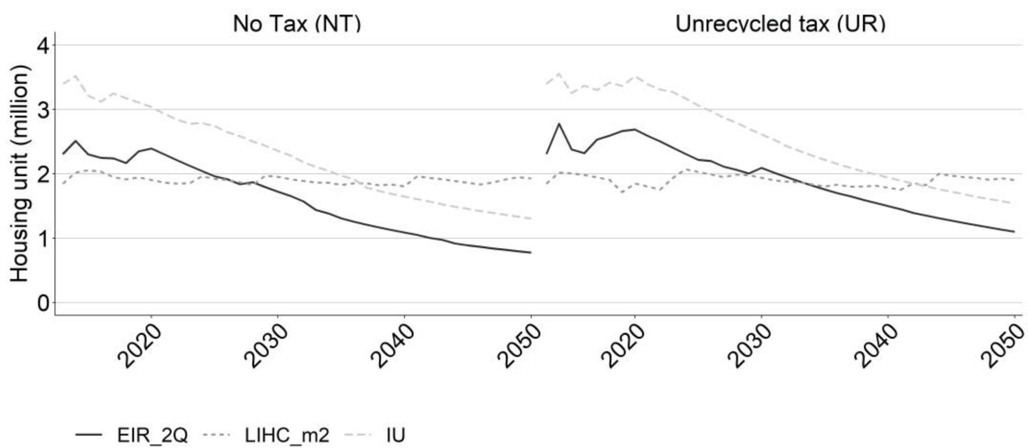

Figure 2. Evolution of the different indicators, with and without tax

Comparing the evolution of the EIR and IU under different scenarios in Figure 3, we see that while the lump-sum recycling hardly affects the retarding effect of the carbon tax, the subsidy recycling offsets it, first partially and totally from 2025 onwards. Subsidy recycling does even better than the no-policy scenario when one considers the IU indicator in the medium- to long-term.

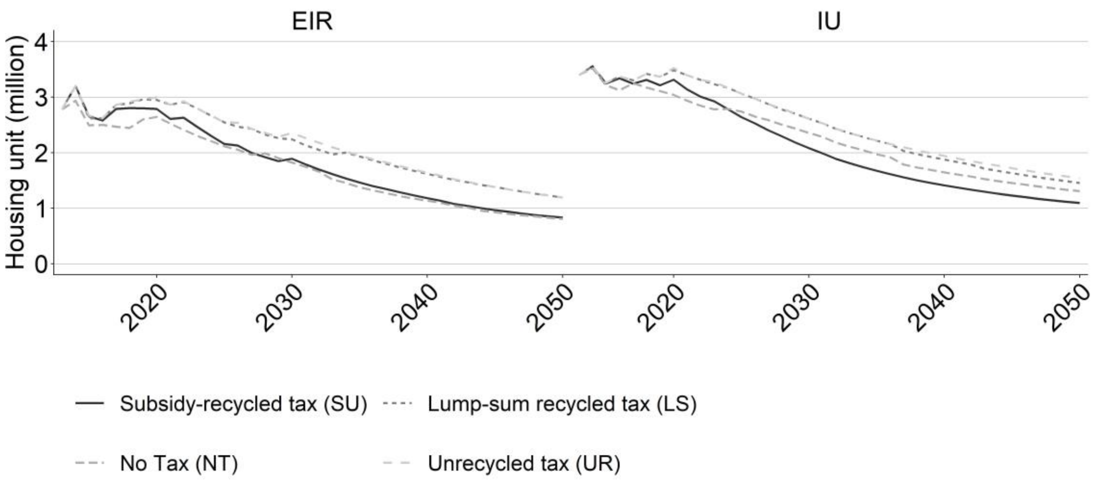

Figure 3. Evolution of fuel poverty (EIR and IU) under different scenarios

We now disaggregate these evolutions by type of housing for the EIR. Figure 4 displays the composition of the indicator by performance of the dwellings. It shows that, quite consistently across scenarios, fuel poverty is restricted to performance labels G, F and E. In other words, fuel poverty is virtually inexistent in higher labels (except a small fraction of class D under the carbon tax). Progress on the indicator is for the most part due to the renovation of G dwellings.

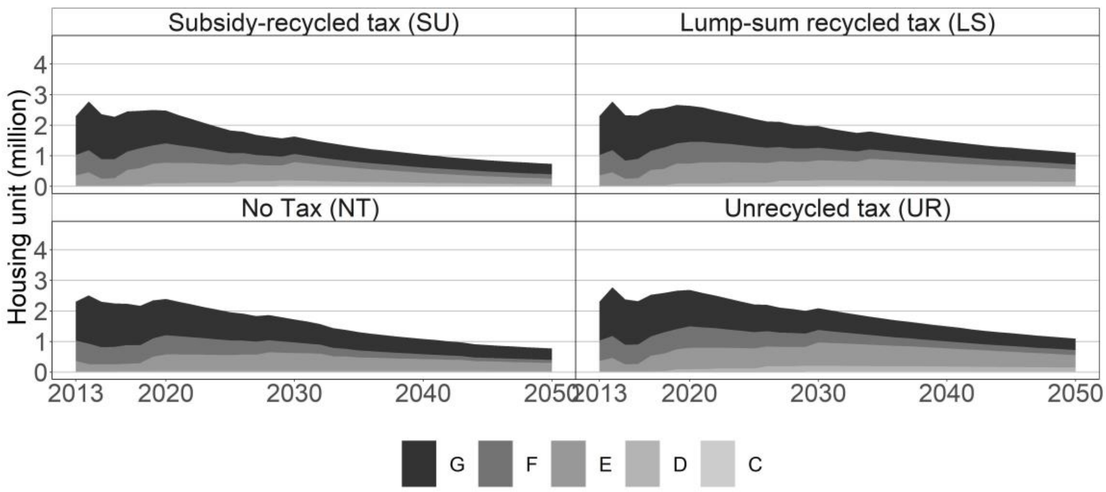

Figure 4. EIR, split by energy performance label, under different scenarios

Figure 5 shows the composition of the indicator by tenancy status of the occupant. We see that fuel poverty alleviation by and large benefits owner-occupiers and social housing beneficiaries. In contrast, the number of tenants in private housing that fall within the EIR<10% criterion is constant over time and unaffected by the scenario considered. This means that no policy succeeds in reducing fuel poverty in private rented housing. This is due to both the parameterization of short investment horizon in rented dwellings and the calibration of the model against retrofitting rates which are significantly lower for rented dwellings than for owner-occupied dwellings – 1.9% vs. 4.3%, estimated from ADEME (2016).[4]

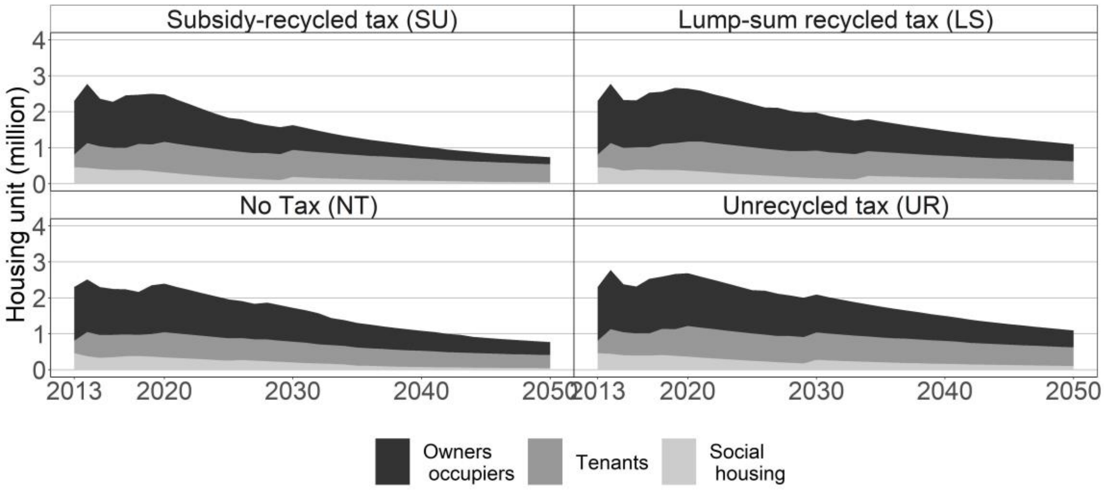

Figure 5. EIR, split by the occupant's tenancy status, under different scenarios

Environmental outcome

We now examine the energy savings achieved under the different scenarios. In Figure 6, we see that the effect of the lump-sum recycling is indistinguishable from that of the unrecycled tax. In contrast, the energy efficiency recycling produces substantially more savings – about 50% more than the savings attributable to those two options in excess of what is achieved without policy in 2050.

[4] As a robustness check, we assign the same decision parameters to landlords as to owner-occupiers and verify that fuel poverty declines at the same rate in the two segments.

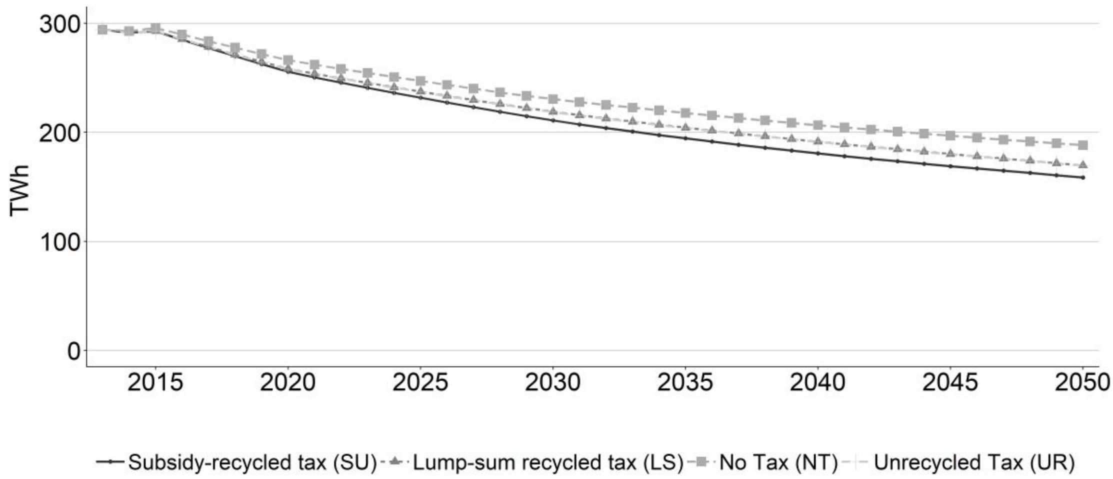

Figure 6. Energy consumption under the different scenarios

Economic outcome

Lastly, we compare the leverage effect of each policy, measured as the renovation expenditures additional to the no-policy scenario that are induced by one euro of public subsidy (Figure 7). While the unrecycled and lump-sum recycled taxes are again indistinguishable, leverage is much higher under the energy efficiency subsidy recycling. In other words, the policy is much more efficient per euro levied when tax proceeds are used to finance the renovation of dwellings owned by low-income households. This is due to the negative correlation observed in the Phébus data between household income and the energy efficiency of their property; therefore, targeting subsidies to low-income households is an indirect way to allocate public money to the most cost-effective renovation options. As the correlation is plausibly general to European countries, the associated policy insight is to some extent general.

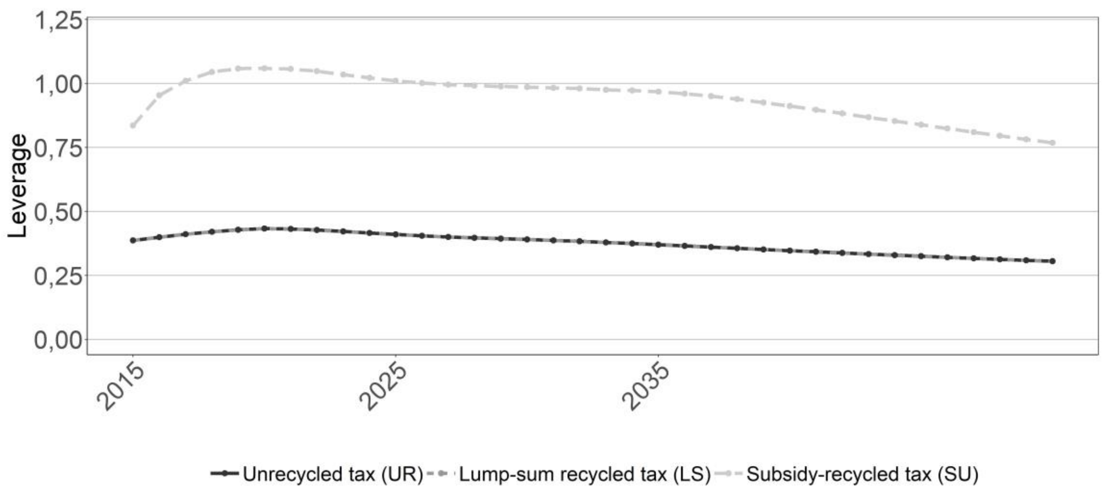

Figure 7. Leverage under the different scenarios

Conclusion

This paper shows that recycling the revenue of the French carbon tax as an energy efficiency subsidy generates a triple dividend: fewer people suffer from fuel poverty and more energy savings are achieved, with higher leverage. In particular, subsidy recycling totally offsets the regressive effect of the carbon tax from 2025 onwards. In contrast, lump-sum recycling hardly does any better than the unrecycled tax, in any respect. Finally, no recycling effectively addresses fuel poverty in private, rented housing.

These results are established within a partial-equilibrium framework which ignores broader economic effects and under the restrictive assumption that tax receipts are rebated on the same base as that in which they are collected. Still, that base is relevant for it is at the heart of the public debate, perhaps because it is most salient, tangible to the general public. This opens room for policy linkages between the carbon tax and public subsidies for home energy retrofits. In our assessment, the carbon tax generated €840 million Government revenue in 2016 from household heating consumption; this amount is poised to increase in the future with increasing tax rates. Meanwhile, the Government spent about €2 billion in subsidy programmes for energy retrofits, including income tax credits, zero-interest loans and VAT reductions (IGF and CGEDD, 2017). Better coordinating these resources and expenses could be a way to improve their acceptability. A targeting of subsidies seems also necessary to reduce fuel poverty in private rented housing.

Further research could include examining other forms of subsidies (for instance, ad valorem, as is the current tax credit programme, instead of performance-based) and thinking of new indicators that better account for the effect of renovation on property value, hence total household wealth– a phenomenon not captured in the present assessment. This would provide a broader picture of poverty issues, not limited to energy usage.

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