Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of the
Environment, Traffic, Energy and Communications DETEC

Swiss Federal Office of Energy SFOE

Final report 21.10.2016

SEPIA

Social Cushioning of Energy Price Increases and Public Acceptability

Date: 21 October 2016

Place: Bern

Contracting body:

Swiss Federal Office of Energy SFOE
Research Programme Grids
CH-3003 Bern
www.bfe.admin.ch

Co-funding:

Haute Ecole de Gestion de Genève (HEG), CH-1227 Carouge

Contractor:

Econability F. Vöhringer
Fischermatt 12
CH-3127 Mühlethurnen
www.econability.com

Haute Ecole de Gestion de Genève (HEG)
Route de Drize 7
CH-1227 Carouge
www.hesge.ch

Université de Genève (UNIGE)
40 Boulevard du Pont d'Arve
CH-1211 Genève 11
www.unige.ch

Ecole Polytechnique Fédérale de Lausanne (EPFL)
Station 1
1015 Lausanne
www.epfl.ch

Authors:

Frank Vöhringer, Econability, voehringer@econability.com
Stefano Carattini, HEG, stefano.carattini@hesge.ch
Andrea Baranzini, HEG, andrea.baranzini@hesge.ch
Philippe Thalman, EPFL, philippe.thalman@epfl.ch
Frédéric Varone, UNIGE, Frederic.Varone@unige.ch
Dario Stocker, Econability, stocker@econability.com
Wolfgang Knoke, Econability, knoke@econability.com

SFOE Head of domain and Programme manager: Anne-Kathrin Faust, anne-kathrin.faust@bfe.admin.ch
SFOE Project manager: Boris Krey, boris.krey@bfe.admin.ch
SFOE Contract number: SI/500806-01

Swiss Federal Office of Energy SFOE
Mühlestrasse 4, CH-3063 Ittigen; Postal address: CH-3003 Bern
Phone +41 58 462 56 11 · Fax +41 58 463 25 00 · contact@bfe.admin.ch · www.bfe.admin.ch

1. Zusammenfassung

Ohne gesellschaftliche Akzeptanz können CO_2-Abgaben in aller Regel weder eingeführt noch erhöht werden, auch wenn sie der effizienteste Weg zur Umsetzung energie- und klimapolitischer Ziele sein mögen. Eine verbreitete Befürchtung ist jene einer möglicherweise regressiven Wirkung auf die Einkommensverteilung. Wir untersuchen die Auswirkungen einer sozialen Abfederung und anderer Rückverteilungsvarianten einer CO_2-Abgabe im Hinblick auf Einkommensverteilung und Effizienz sowie mögliche Gestaltungsoptionen zur Förderung der gesellschaftlichen Akzeptanz. Unsere Analyse basiert auf Simulationen mit dem Allgemeinen Gleichgewichtsmodell GENESwIS und auf einer repräsentativen empirischen Erhebung mit 1'200 Befragten. In der Umfrage wurde die Akzeptanz verschiedener Varianten einer CO_2-Abgabe mit einem Auswahlexperiment untersucht. Die Befragten wurden über Auswirkungen der Gestaltungsvarianten in Bezug auf Umwelt, Verteilung und Wettbewerbsfähigkeit informiert, die sich an den Ergebnissen der Simulationen mit GENESwIS orientierten.

Dieser innovative Ansatz führt zu mehreren neuen und überraschenden Ergebnissen: Wird die umweltpolitische Wirksamkeit einer CO_2-Abgabe klar kommuniziert, verringert dies den Wunsch nach umweltpolitischer Zweckbindung. Die Betonung von Verteilungseffekten führt zu einer Bevorzugung progressiv wirkender Varianten. Hierbei sticht die Pro-Kopf-Pauschale heraus: Allein die Hervorhebung ihrer Verteilungseffekte macht sie zu einer der am häufigsten gewählten Varianten.

Kombinationen aus umweltpolitischer Zweckbindung und Pro-Kopf-Pauschalen, wie sie in der Schweiz praktiziert werden, haben Vorzüge bezüglich Akzeptanz und im Hinblick auf umwelt- und verteilungspolitische Ziele. Gemäss unseren Simulationen reicht es aus verteilungspolitischer Sicht aus, nur einen Teil der Einnahmen pauschal rückzuverteilen. Allerdings ist die effiziente Verwendung von Einnahmen für umweltpolitische Zwecke im grösseren Rahmen schwierig. Zudem ist die Rückverteilung über Steuersenkungen wirtschaftlich effizienter. Dieses letzte Argument ist jedoch schwer zu vermitteln, so dass die Vorteile für die Umwelt das Argument für eine Ökosteuerreform sind, das deutlich mehr Menschen erreicht.

2. Résumé

Bien que les taxes environnementales soient un instrument efficient pour atteindre les objectifs des politiques climatique et énergétique, elles ne sont pas toujours socialement acceptées. Une crainte fréquente est que ces taxes pourraient avoir un effet régressif sur la distribution des revenus. Dans ce projet, nous analysons dès lors les impacts sociaux de ces taxes, ainsi que plusieurs options pour la redistribuer les recettes fiscales, de sorte à maximiser leur acceptabilité sociale et politique. Nos analyses se basent sur des simulations avec le modèle d'équilibre général GENESwIS et sur des données provenant de 1'200 réponses à une enquête nationale représentative, basée sur la méthode des choix discrets. L'objectif principal de l'enquête était de vérifier l'acceptation sociale de différents types de taxes carbone. Les participants à cette enquête étaient informés des conséquences de différentes taxes carbone sur les émissions, les inégalités sociales et la compétitivité des entreprises, effets qui ont été estimés par le modèle GENESwIS.

Cette recherche originale a produit plusieurs résultats innovants et surprenants. En informant correctement les personnes enquêtées sur l'efficacité environnementale des taxes, on peut réduire leur demande d'affecter l'utilisation des recettes fiscales à la seule protection de l'environnement. De même, en présentant les impacts redistributifs des taxes, on augmente leurs préférences pour une restitution forfaitaire des recettes de la taxe. Une fois bien expliquée, cette option devient même la plus attractive pour les personnes ayant répondu à notre enquête.

Combiner une distribution environnementale et forfaitaire des recettes de la taxe sur les émissions de carbone, comme cela est actuellement pratiqué en Suisse, paraît donc une option acceptable. Selon nos simulations, réserver une partie des recettes de la taxe pour une distribution forfaitaire suffit pour réduire les craintes émises quant aux conséquences sociales néfastes d'une taxe environnementale. Néanmoins, il reste difficile de concevoir, à grande échelle, une affection des recettes à la protection de l'environnement. De plus, réduire d'autres taxes grâce aux recettes de la taxe carbone semble plus efficient d'un point de vue économique. Comme ces arguments sont difficilement compréhensibles pour une majorité de citoyens, il semble encore et toujours plus aisé de légitimer une taxe carbone par ses impacts environnementaux.

3. Summary

Without public acceptance carbon pricing instruments cannot be implemented, even if they may be suitable for efficiently pursuing climate and energy policy goals. One frequent concern is that such levies could have a regressive effect on income distribution. We investigate how social cushioning and other revenue recycling options affect income distribution and efficiency, and how they can be defined such that public acceptance is maximized. We base the analysis on simulations with the general equilibrium model GENESwIS and on a representative national survey with a total of 1'200 respondents. In the survey, we tested the acceptability of alternative designs of a CO_2 levy with a choice experiment. Survey respondents were informed about environmental, distributional and competitiveness effects of each carbon tax design, according to simulation results from GENESwIS.

This original setting generates a series of novel and surprising results: Providing information on the expected environmental effectiveness of carbon taxes reduces the (generally strong) demand for environmental earmarking; Making distributional effects salient generates an important demand for progressive designs. The case of lump-sum recycling is particularly striking: it is sufficient to show its desirable distributional properties to make it one of the most preferred designs.

Combinations of environmental and lump-sum recycling, as currently implemented in Switzerland, seem attractive considering acceptance as well as environmental and equity considerations. According to our simulations, reserving a share of the revenues for lump-sum recycling is sufficient to address social concerns. On the other hand, effective environmental recycling is difficult to design on a large scale, and recycling through tax cuts is economically more efficient. As the latter argument is understood by few, environmental motivation still remains the much more prevalent argument for environmental tax reform.

Contents

1 Introduction

1.1 Relevance of the topic

In the face of climate change, depleting fossil fuel resources and acceptance issues with nuclear power, it seems ineluctable for energy prices to increase. The Swiss New Energy Policy scenario sets ambitious goals towards a more efficient and less carbon intensive energy system. If this scenario is to be converted into a set of policies, obtaining public acceptance is imperative. In a democratic system like the Swiss, public acceptance is of especially great importance as political parties and the general public can in many cases block or alter legislation. However, various studies and past voting results in Switzerland have shown that it can be difficult for environmental levies to find a majority among voters (Thalmann 2004). It has also been shown that the way environmental tax revenues are used has an impact on the public opinion of such measures. According to Thalmann (2004), consumers prefer measures which are designed to use revenues for energy or environmental causes. One important concern is, however, that levies raised on energy goods could have a regressive effect. This distributional effect can be countered by specifically targeted tax revenue recycling options. Therefore, it is of great interest to find out both how social cushioning and other recycling options affect income distribution and efficiency, and how the revenue recycling and cushioning options can be defined such that public acceptance is maximized.

1.2 Objective of the study

The project aims to investigate the acceptability of various designs for CO_2 levies, with a focus on distributional effects and social cushioning measures. More precisely, we investigate how social cushioning and other revenue recycling options affect income distribution and efficiency, and how they can be defined such that public acceptance is maximized. We base the analysis on simulations with the general equilibrium model GENESwIS and on a representative national survey. In the survey, we tested the acceptability of alternative designs of a CO_2 levy with a choice experiment. Survey respondents were informed about environmental, distributional and competitiveness effects of each carbon tax design, according to simulation results from GENESwIS.

GENESwIS, a computable general equilibrium model for Swiss energy and climate policy analysis, is enhanced in this project to distinguish between different types of households. The disaggregation of the households is done according to criteria regarding place of residence (city, agglomeration and periphery) and regarding the composition of the household (kids, no kids and retired). A further disaggregation of these categories is conducted according to living standards.

To address the question of the acceptability of cost effective climate policy, the design of the representative national survey generally draws on stated preferences under partial information. A total of 1’200 respondents were contacted by phone and questioned with regard to their preferences related to the magnitude of carbon taxes for which also various design options exist. In the survey, we tested the acceptability of alternative designs of a CO_2 levy with a choice experiment. Survey respondents were informed about environmental, distributional and competitiveness effects of each carbon tax design, according to simulation results from GENESwIS. Furthermore, we analyze voting behavior in a large ballot on energy taxes in Switzerland, rejected in 2015 by more than 2 million people.

The remainder of the report shall be organized as follows: In the second chapter, the modeled scenarios are introduced. In the third chapter, the computable general equilibrium (CGE) model simulations are described and their results are presented. In the fourth chapter, the public acceptability of energy levies and taxes is explored with the help of a survey. Chapter 5 concludes.

Several appendices show the scientific output of the project, including papers with results from an additional (non-representative) survey conducted in Geneva and a note regarding the assessment of answers to questions that we were able to add to the VOX survey on the popular initiative for replacing the value added tax with an energy tax.

2 Scenarios

2.1 Basic considerations

In the CGE model runs, two basic scenario types are distinguished, depending on the origin of the energy price increase (see Table 1). The main set of scenarios (domestic scenarios) assumes a reform of the CO_2 levy[1] to comply with the CO_2 targets of the new energy policy. Another set of scenarios (international conflict scenarios) assumes energy price increases due to developments in global fossil fuel markets. The idea is that political crisis could lead to temporary price increases for crude oil and natural gas.

As a second scenario dimension, the two basic scenarios are combined with different revenue recycling and cushioning options, which leads to a total number of 12 counterfactual scenarios (see Table 1). These scenarios are evaluated relative to a baseline scenario. In the following, the two scenario dimensions as well as the baseline scenario shall be explained more in depth.

Table 1: Counterfactual scenarios

	Domestic Policy	International conflict
Recycling through taxes		
Income tax	IncTax	
Value added tax	VAT	
Lump-sum recycling		
Lump-sum per capita	LumpSum	LumpSum_F
Social benefits	Social	SocKids_F
Social benefits + child benefits	SocKids	SocKids_F
Social + child + retirement benefits	SocMix	SocMix_F
Recycling through imported carbon offsets		
Offsets counting to domestic target	Offsets	
Offsets for additional abatement	Abate	

2.2 Baseline

The GHG emissions trajectory in the baseline scenario originates from Prognos 2012a. The report's *weiter wie bisher* (engl.: business as usual) scenario provides information on the likely future development of the

[1] In the international literature, the term *CO_2 tax* is more common than *CO_2 levy*. In Switzerland, the term *CO_2 levy* refers to the fact that the levy comes with provisions for complete revenue recycling, which makes it neutral in terms of the public budget. Under this terminology, a *tax* is something which increases the public budget. In this report, we use the term *CO_2 levy* when we refer to the existing Swiss levy. To be in line with the usual terminology in environmental economics, we still use expressions such as *tax base, tax rate*, *carbon taxation, environmental taxes* and alike. This does not imply that we question the revenue neutrality of the levy.

CO_2 emissions. These were supplemented with historical data on non-CO_2 emissions.[2] We assume that their share in total emissions remains constant over the modeled time horizon.

The paths of fossil fuel prices were estimated from a more recent source than Prognos 2012a, the World Energy Outlook 2014 (IEA 2014). Import prices for energy carriers are set according to projections of the World Energy Outlook 2014. A logarithmic fit was used to extrapolate the missing years. Prices in CHF of 2015 can be found in Table 2.

Table 2: World energy prices (CHF_{2015} /GJ)

	2015	2020	2025	2030	2035
Oil	17.25	17.99	18.75	19.54	20.37
Gas	9.99	10.34	10.71	11.08	11.47

Source: IEA 2015 and own calculations

Labor growth in the model is composed of two factors: (1) active population growth and (2) labor productivity growth. The full-time equivalent forecast is taken from the scenario A-00-2015 of the Federal Statistical Office. The State Secretariat for Economic Affairs estimate a productivity growth of 0.9% per year (Surchat 2011). We combine the two to get total labor growth. From these values, an average annual GDP growth rate of approximately 1.2% results in the baseline.

The idea behind the calibration of SEPIA's baseline scenario is to reproduce the set of parameters mentioned above. Since GENESwIS is a CGE model and hence has a different structure than the models used by Prognos, only a limited number of target parameters from Prognos' model were deliberately chosen for baseline replication. In the GENESwIS world, hardly justifiable assumptions would be required to replicate WEO2014 import prices, Prognos end user prices and Prognos demands at the same time.

Based on these considerations, we replicate basic macroeconomic projections for labor and GDP growth and, using import prices for fossil fuels from IEA 2014, GHG emissions paths per type of fuel input and electricity demands from Prognos 2012. It follows from the aforementioned that variables which are not targeted in the calibration will be somewhat different from the Prognos results.

The following baseline policies are implemented:

- Emissions Trading Scheme (ETS): sectors that belong to the ETS must buy permits for CO_2 emissions due to heating fuels and for geogenic emissions. Aviation is included in the ETS scheme in 2020 (in the model; start in 2020 due to 5-year time-steps) and trades ETS permits for CO_2 emissions from transport fuels. As permit price projections by Prognos 2012a are much above current prices and projections, we replace them by more modest assumptions which are close to the upper end of current projections. We assume a price of 10 CHF per ton of CO_2e in 2015 and price increases of 10% per year.
- A CO_2 levy on light heating oil and natural gas is applied to non-ETS sectors and household consumption. The CO_2 levy is set at the following levels: 60 CHF_{2015} /t in 2015 and 84 CHF_{2015} /t in 2020 and following years.

[2] The UNFCCC's GHG inventory was used for non-CO_2 data, see http://unfccc.int/ghg_data/ghg_data_unfccc/items/4146.php.

- Subsidy for the buildings program: 280 mio CHF from the CO_2 levy's revenue is used to incentivize insulation. The remainder of the CO_2 levy's revenue is recycled as a lump-sum transfer to households.

2.3 Energy price increases

2.3.1 Domestic scenarios

The New Energy Policy (NEP) sets goals for both energy demands and greenhouse gas (GHG) emissions. In the domestic policy scenarios, we set NEP quantity targets for total GHG emissions. We attain the domestic policy trajectories in GENESwIS by imposing endogenous levies on CO_2 emissions from non-ETS sources (including transport). Table 3 provides a comparison of the domestic policy and baseline trajectories.

Table 3: Greenhouse gas reduction targets for the domestic policy scenarios

		2015	2020	2025	2030	2035
CO_2-eq emissions[3] (Mt)	Baseline	50.5	47.6	44.3	41.4	38.7
	Domestic policy		41.2	35.1	29.4	24.9
	% Δ		-13.5%	-20.8%	-28.9%	-35.6%

Source: Prognos 2012a and own calculations

The NEP scenario assumes crude oil prices (90 US$/t in 2035) that differ from the WWB baseline (113 US$/t in 2035), because globally more ambitious climate policy reduces oil demand and thus net oil prices. Despite this, we use the WWB import price assumptions also for the domestic policy scenario. This allows for better comparability, and it is in line with the ceteris paribus approach that prevails in CGE scenario design for good reasons.

2.3.2 International crisis scenarios

Despite the recent slump in crude oil prices, real energy price increases are expected internationally due to depletion of conventional fossil fuel resources, but also due to investment needs in European electricity generation and transmission capacities. Furthermore, political conflict and/or insecurity about political developments have shown the potential to push crude oil and natural gas prices much higher than what pure cost considerations might suggest.

To capture the important differences between price increases that are induced domestically or abroad, we add a scenario which is driven by international price increases only, i.e. higher import prices for fossil fuels and possibly electricity (foreign scenarios, labeled "_F"). The rationale for this scenario is that also in the case where energy price increases arise from international developments, there could be a desire to mitigate the social consequences of these changes. In this event, however, the financing of social cushioning measures is complicated by the fact that the price increases are not linked to higher public revenues, but are likely to even reduce overall tax revenues.

[3] In GENESwIS, we use the Kyoto definition for GHG emissions, but assume non-CO_2 GHGs and LULUCF emissions to follow business as usual paths in all scenarios.

It is difficult to find a plausible scenario for large international price increases that go much beyond the WWB baseline assumptions: In the original NEP scenario, import prices for crude oil are lower than in the baseline. In the 2014 IEA World Energy Outlook (WEO), the highest projected energy prices are found in the Current Policies Scenario, which – unlike the New Policy Scenario used for the projection of fossil fuel prices in the baseline scenario for this report – does not include recently introduced and announced policies. Nominal numbers e.g. for crude oil are above the Prognos 2012a baseline assumptions, but as the WEO 2014 uses more recent (i.e. 2013) US Dollars, prices in the Current Policies Scenario converted into CHF are not much different from Prognos 2012a baseline assumptions. Furthermore, the WEO does not expect large price increases for electricity in Europe.

Significant international price increases beyond the baseline assumptions are conceivable mostly in the event of severe political crisis. Therefore, we define the scenario with foreign price increases as an international crisis scenario, assuming a temporary 50% price increase for world market prices of crude oil and natural gas in the periods 2020 and 2025 (the SEPIA version of GENESwIS has 5-year periods). For this scenario, revenues for social cushioning shall be generated by increasing income taxes to generate additional tax revenues of 1 bio. CHF.

2.4 Revenue recycling and social cushioning

The second scenario dimension concerns the full recycling of additional tax revenues associated with the changes in scenario dimension 1. In CGE counterfactual simulations, revenues of all taxes change, but overall revenue neutrality is assured by an equal yield constraint that keeps public goods provision constant. When domestic CO_2 and energy taxes are increased, it creates room for lowering other taxes or for transfers or subsidies according to the chosen recycling or cushioning option in dimension 2. As discussed above, international price increase scenarios are likely to reduce tax revenue, which means that, in order to keep public goods provision constant and to finance social cushioning measures, increased (marginal) income tax rates are assumed.

2.4.1 Recycling through taxes

Regarding the recycling through tax reductions, two alternatives are simulated using the two most important types of taxes: a proportional value added tax reduction (scenario “VAT”) and a proportional reduction of marginal tax rates on labor income (scenario “IncTax”). The tax recycling variants are combined with the domestic policy scenario, but not with the international crisis scenario, because it makes little sense to raise additional revenue through income taxes to then recycle these revenues again through the income tax. Also, we do not intend to simulate the consequences of shifts between income tax and value added tax.

2.4.2 Lump-sum recycling

Lump-sum transfers to all households (scenario “LumpSum”) are a main element of the current approach for recycling the revenue of the CO_2 levy. Lump-sum recycling is usually not recommended by public economists, because they tend to search for opportunities to reduce the excess burden of existing taxation. However, Imhof (2012) has shown for Switzerland that lump-sum recycling can be preferable to tax reductions for distributional reasons, while the difference in total excess burden is not very prominent.

For better effectiveness in addressing distributional issues, lump-sum transfers could be differentiated to become targeted social policy (scenario “Social”). In reality, such social policy comes in many forms including allowances and benefits of various kinds. Effective targeting to low income groups is known to be a major challenge in this policy area. Especially, subsidized premiums for health insurance are granted to many middle class households. We thus assume that only 70% of the transfers go to households in the lowest income category, 25% to the second lowest, and 5% to the third lowest.

Targeting groups of society which are considered to be especially vulnerable to energy price increases can take many forms. In the model – and also in reality – vulnerable groups need to be identifiable on the basis of easily observable personal attributes. In the analysis of the household data, two such attributes become evident:

- Statistically, having children increases the risk of possessing a low equivalized disposable household income.
- Similarly, being retired increases the risk of having a low equivalized disposable household income. However, retired people will own, on average, more assets.

We thus introduce two more lump-sum scenarios. Both of them use 50% of the revenues for targeted social policy as described above. The other 50% of revenues are used for

- child benefits (scenario “SocKids”), i.e. an equal transfer per child,
- child benefits and first pillar retirement benefits (scenario “SocMix”), i.e. children and retired persons receive equal transfers per capita.

According to the base year household data we use, there are 1.20 mio. children and 1.24 mio. retired persons in Switzerland.

2.4.3 Recycling through carbon offsets

For green taxes, existing literature suggests that survey respondents favor recycling for environmental purposes. Mostly due to the limited disaggregation of the household data, it is difficult in the model to represent subsidies for renewables or public transport in a satisfying way. To maintain the notion of green funding, we simulate revenue recycling into carbon offsets. Given that domestic offsetting (in combination with voluntary commitments) seems to explore its limits already at the moment, we concentrate on imported offsets. These are assumed to be available at the same price as GHG allowances in the ETS. We simulate two alternative offset scenarios:

- Imported offsets count towards the CO_2 target of the domestic scenario (scenario “Offsets”). As abatement can be purchased from abroad, this scenario is not necessarily in line with the Swiss domestic abatement objectives which have been communicated (e.g. -30% GHG emissions in 2030 compared to 1990). The recycling via offsets lowers the CO_2 levy which is necessary to reach the overall target.
- Foreign offsets purchased from revenue recycling add to the overall GHG abatement (scenario “Abate”). The domestic reduction targets have to be attained with domestic measures or through the existing ETS.

3 Simulations with GENESwIS

3.1 Distributional effects of CO_2 levies in applied general equilibrium

Putting a price on carbon by imposing a CO_2 levy or installing a cap and trade system affects real household income in different ways. The composition of expenditure effect unfolds through rising prices for carbon intensive commodities. Households who spend a larger share of their income on these goods bear a higher financial burden. This impact is usually regressive in income, because the shares of expenditure for gasoline and electricity tend to be higher for poor than for rich households (see e.g. Poterba 1991). Changing factor prices determine the composition of income effect. For example, capital income from sectors which are confronted with falling relative factor prices decreases, unless capital is internationally fully mobile. This is a progressive impact as long as capital income accounts for a higher share of income for richer than for poorer households, which is usually the case.

Composition of income effects can be larger than composition of expenditure effects, even more so when revenue recycling enters the picture. A distributional analysis is incomplete without regard to the use of revenue raised from carbon pricing. Hence, partial approaches are unable to explore impacts of carbon taxes in a meaningful way, and general equilibrium analysis becomes necessary. Whereas many studies have addressed economic impacts of carbon pricing on aggregate levels, studies tackling distributional effects are much less frequent.

Metcalf 1999, although he finds a US carbon tax to be regressive, points out that any impacts on income distribution from environmental taxation can be adjusted through a suitable choice of the revenue recycling regime. Even quite regressive effects of carbon pricing can be turned into neutral or at least mildly progressive distributional outcomes. This has been confirmed by many studies (e.g. Barker/Köhler 1998, Rausch et al. 2011), especially for lump-sum per capita recycling.

Distributional consequences of carbon taxation differ a lot between regions. Oladosu and Rose 2007 highlight peculiarities for their region of investigation, the Susquehanna River Basin in the north-eastern USA. They find carbon taxation at a tax rate of 25 US$ per ton of CO_2 to be mildly progressive. This is mainly due to a dominant composition of income effect with a slightly unusual background: Apart from a decline in capital income which hits households in higher income brackets harder than poor households, employment declines across all household groups. Higher income households suffer a larger loss, because they tend to earn higher wages and are employed in sectors which are more strongly affected by the overall decline in output. Under these circumstances, even a uniform percentage reduction of the income tax strengthens the progressivity of the impact

Another regional study from Beck et al. 2015 shows a highly progressive carbon tax even before revenue recycling. It investigates the distributional impact of the 30 C$ carbon tax imposed on all fossil fuel combustion in the Canadian Province of British Columbia. Electricity is mostly generated from hydro, which translates into a rather small composition of income effect. On the other hand, the composition of income effect is large, because capital moves out of the region due to high energy prices and puts pressure on labor supply – a factor which is much less mobile. Consequently, real wages decline, affecting higher income households more, due to their higher dependence on labor income.

Research on developing or emerging economies underlines even further, how much distributional impacts of carbon taxation depend on economic structure and conditions (see the anthology from Sterner 2011). In an analysis of a reduction of vehicle fuel subsidies in Indonesia, Yusuf and Resosudarmo 2011 discover evidence for a rather strong progressivity. Higher income households spend a larger share of income on vehicle fuels and commodities closely associated than poorer households, who in many cases cannot even afford public transport. Furthermore, the poorer households have very little access to income from factors affected by the tax reform.

Liang and Wei 2012 emphasize the different impacts of carbon taxation and revenue recycling options in urban and rural households in China. The carbon tax as well as most of the explored revenue recycling schemes tend to widen the existing gap in income between urban and rural households. Urban households bear a higher burden of the income tax and receive a higher share of government subsidies. Therefore, revenue redistributed through these channels, e.g. through a uniform income tax rate reduction, increases disparities. Only a lump-sum transfer to households in proportion to the population narrows the urban-rural income gap. It is, however, inefficient in the sense that in the long term all incomes decline more significantly than in a reference scenario without revenue recycling.

For Switzerland, useful insights are delivered by the studies Ecoplan 2012a, 2012b and Imhof 2012. Ecoplan 2012a analyzes the impacts of two scenarios of an ecological tax reform for 2020, 2035 and 2050 with two different levels of ambition, combining a CO_2 levy on fossil fuels and a levy on electricity consumption. Each scenario is supplemented with several revenue recycling options. Only the redistribution through lump-sum per capita transfers leads to an overall progressive effect. In terms of efficiency, however, the lump-sum option is inferior to the other recycling alternatives, which points to a trade-off between efficiency and distributional objectives. Lower income households with children particularly benefit from the lump-sum per capita rebate, whereas no differences were detected between rural and urban households. Imhof 2012 considers three alternative tax policies to achieve a 20% reduction of CO_2 emissions below 1990 levels and combines these with four revenue recycling regimes. Similar to Ecoplan 2012a and 2012b, per capita lump-sum redistribution turns out to be the only progressive option.

3.2 Model structure

3.2.1 Basic set-up

GENESwIS is a dynamic computable general equilibrium (CGE) model of the Swiss economy designed to analyze energy and environmental policies (Vöhringer 2012). For the simulations in the current report, it has been adapted to include multiple households and to a dynamic-recursive design. The time horizon is 2015-2035, in 5-year steps.

Households maximize their utility under a budget constraint. They earn wages by providing labor and receive a rate of return by renting out capital. As a further element of income, they receive social benefits from the Government. Firms maximize profit under technology constraints and the assumption of perfect competition. Non-satiation in consumption and flexible prices imply that demand equals supply in all markets. The Government collects taxes (income tax, value added tax, mineral oil tax, CO_2 levy) and uses the revenue for lump-sum transfers (social benefits) and public goods provision. Equal yield is assumed, i.e. the income tax rate is modified to keep public goods provision constant.

Domestic and foreign goods are assumed to be imperfect substitutes and are aggregated following Armington's description of a small open economy. Capital is modeled as putty-clay to incorporate the rigid character of investment decisions and crowding out of investments. Thus, free capital invested into one type of sectoral capital (industry, energy, housing, or services) cannot be transformed back into capital for another sector. Savings and investments are treated as entirely domestic. GENESwIS exhibits flexible labor supply such that agents can choose between labor and leisure.

3.2.2 Household aggregations

Two alternative household aggregations are considered for the model simulations in this report (also see Figure 1):

- by family type: households with children, without children, and retired population (above 65 years), each of the three categories divided into five classes according to economic standard of living;
- by location of residence: households in cities, agglomerations, and in the periphery, each of the three categories divided into five classes according to economic standard of living.

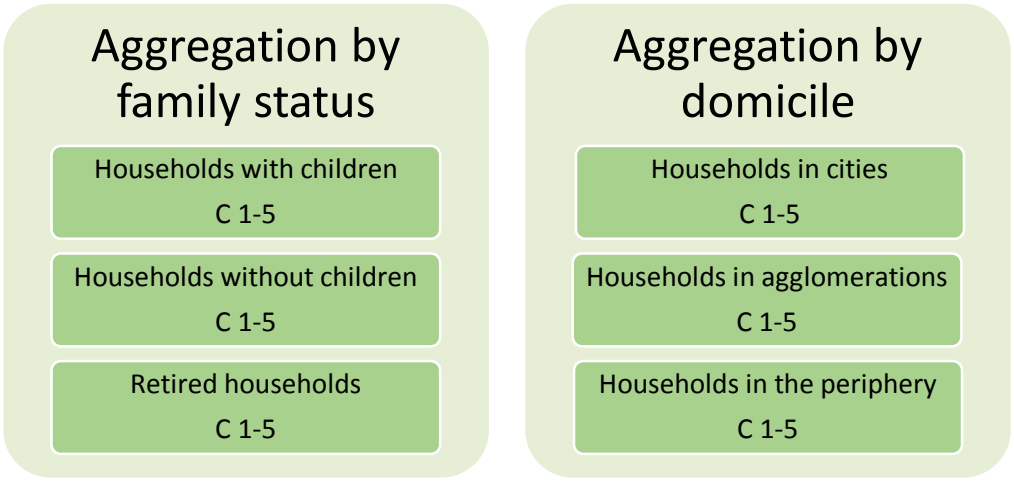


Figure 1: Overview of the households aggregations used in the CGE simulation. "C 1-5" denotes the five classes of economic living standard.

3.2.3 Production and trade

GENESwIS' sectoral aggregation is designed for the analysis of energy and environmental policies. It is displayed in Table 4, while Table 5 presents the commodities that are produced by the sectors or imported. The output of the refinery sector is disaggregated into transport fuels, i.e. Diesel and petrol, light heating oil, and other mineral oil products (see Figure 2). The latter are added to the Rest of Industry commodity. To reflect some flexibility that exists in refinery processes, there is a constant elasticity of transformation of 0.2 between the different outputs. Physical quantities and emissions associated with the different uses of energy carriers are tracked. When they are taxed, this is done in accordance with the fuel specific emission factors.

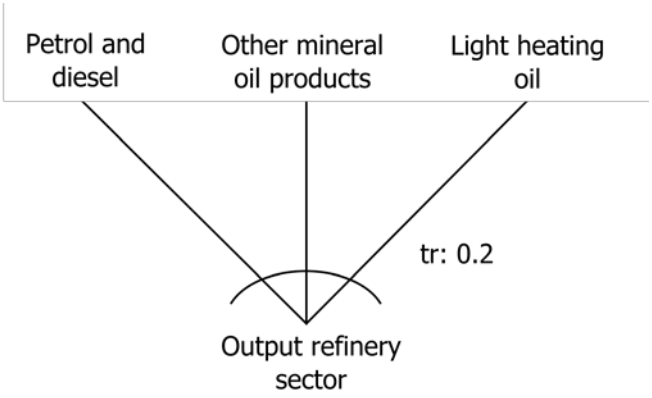


Figure 2: Disaggregation of the refinery production sector

Table 4: GENESwIS' sectors

Energy	Other
Electricity	Food and beverages
Natural gas and district heating	Housing and real estate
Refineries	Transport
	Other emission trading sectors
	Rest of industry
	Rest of services

Table 5: GENESwIS' commodities

Energy	Other
Electricity	Food and beverages
Natural gas and district heating	Housing and real estate
Crude oil	Transport services
Heating fuels	Rest of industry
Transport fuels	Rest of services

In GENESwIS, production functions take the form of sectoral nested constant elasticity of substitution (NCES) production functions. Special attention is given to the use and production of energy. Figure 3 displays the nesting structure for the sectoral NCES production functions (values of the elasticities of substitution are provided in the data chapter 3.3). The top structure, linking capital, labor, energy and other inputs is a standard and recognized structure (see for example Paltsev et al. 2009 and Böhringer et al. 2010). The energy nest, more disaggregated, has been designed with the idea that there is little substitution between different types of energy use, whereas within these types of energy uses different energy carriers or types of production can be substituted to each other.

Transport is subdivided into purchased transport services and own transport, represented by the consumption of transport fuels. The electricity entry on the transport side of the nesting tree represents opportunities for electromobility.

In the heating nest, light heating oil can be substituted by natural gas and district heating. Furthermore, opportunities for better insulation are represented through an entry of rest of industry products. This is where subsidies from the buildings program are applied. The electricity entry on the heating side of the nesting tree represents both electricity for heat pumps and electricity use for appliances.

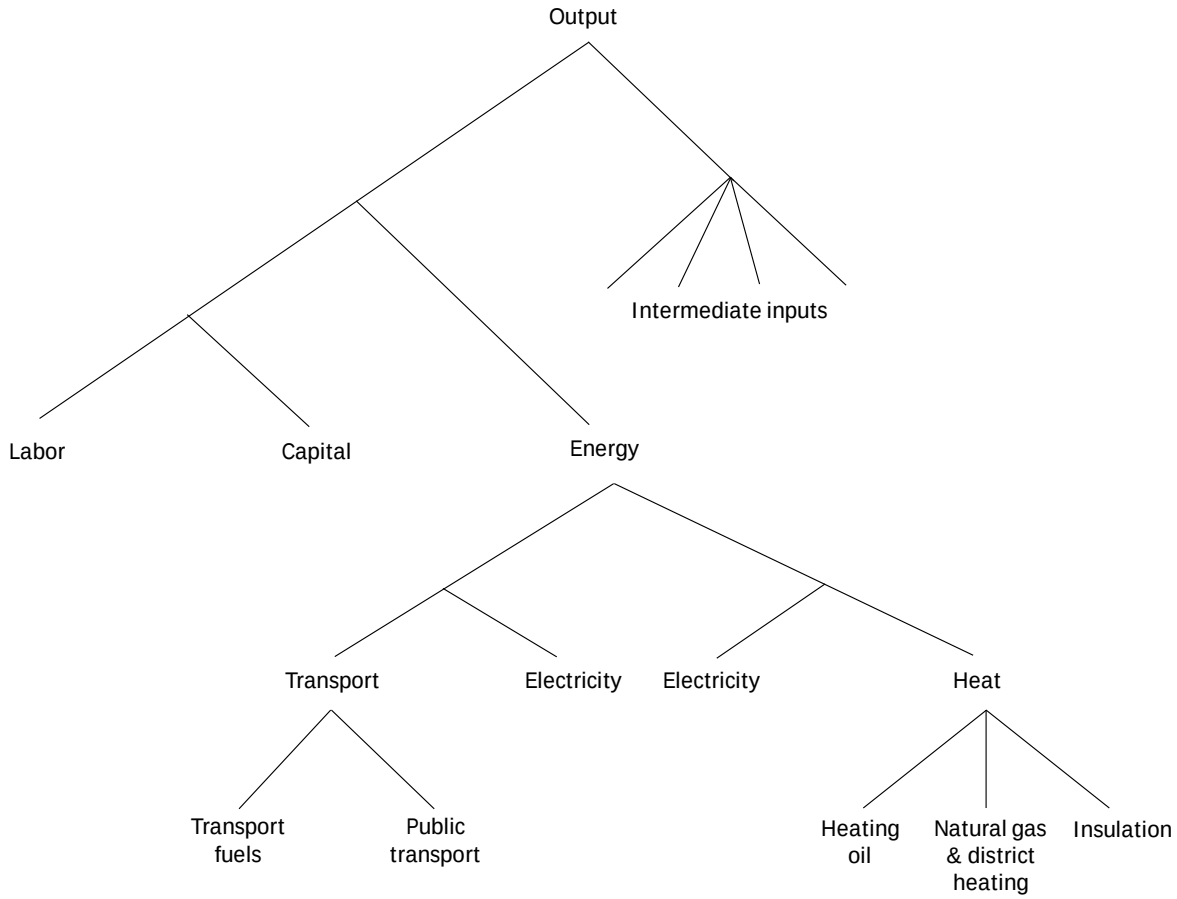


Figure 3: Nesting structure for GENESwIS' production functions.

The Armington representation of trade treats domestic and foreign goods and services as imperfect substitutes. Armington elasticities are taken from GTAP and GTAP-E data (Hertel 1997 and Burniaux/Truong 2002, see Table 7). Crude oil is only imported. Also, no natural gas is extracted in Switzerland. Despite this, the input output table entails some domestic production in the gas sector, which accounts for transport and distribution services. To this, we add the domestic activity of district heating.

3.2.4 Consumption

According to the preferences in their utility function, households choose between consuming goods and services, and enjoying leisure time. Investment is determined by preferences for savings. The nesting structure for consumption is given in Figure 4. Households substitute between the different goods and services with an elasticity of substitution of one (Cobb-Douglas nest). The nesting in energy use is specified precisely as for sectoral production, although different benchmark shares apply, which alters substitution possibilities. Elasticities of substitution for the energy nests are the same as for the Rest of Services sector (values are provided in Table 6 in the data chapter 3.3).

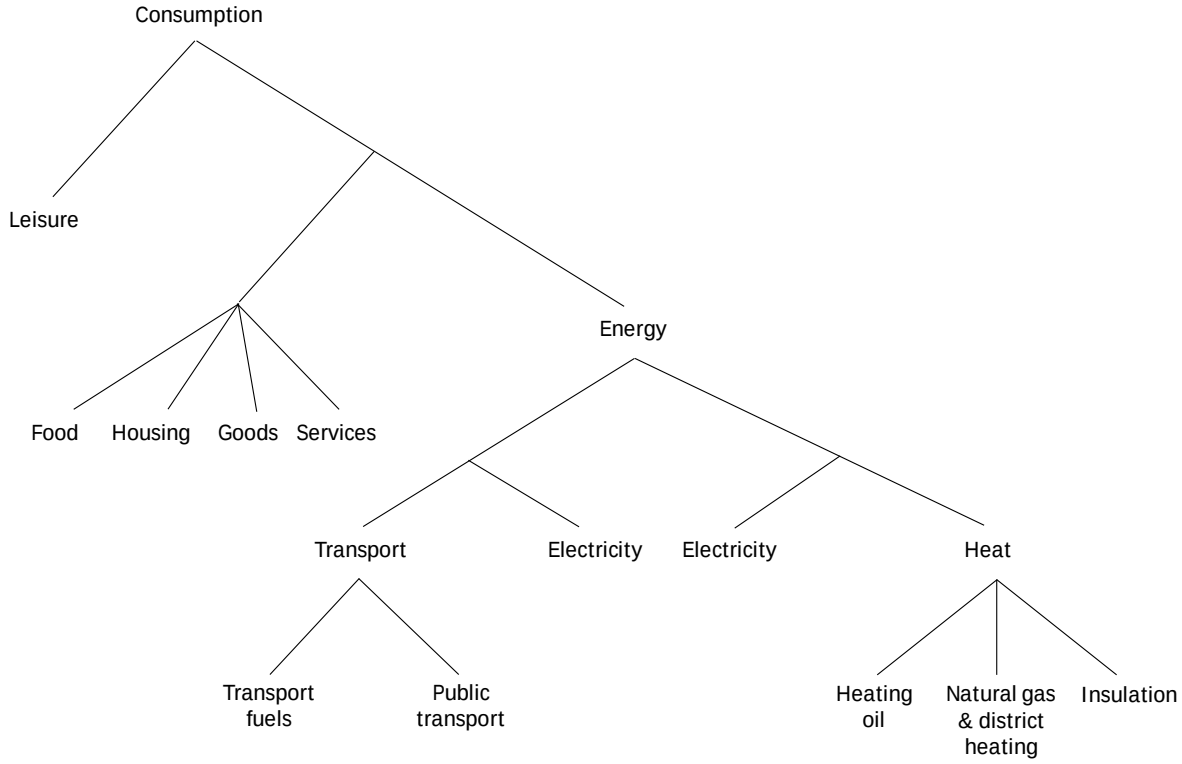


Figure 4: Nesting structure of the GENESwIS model for household consumption.

3.3 Data

GENESwIS is based on the 2008 energy related disaggregation of the Swiss Input-Output Table (IOT) (Nathani et al. 2013). The IOT data is complemented by household data from the HBS (Household Budget Survey) of the years 2007-2009 (Federal Statistical Office 2010b, 2011, 2012). The integration of the IOT and HBS data draws on a similar exercise conducted in Ecoplan 2012b. In the following, we introduce the structure as well as the necessary adaptations to the input data.

3.3.1 Input output data

Work on the Swiss Energy IOT 2008 included the following main tasks:

- The commodity "Coke and refined mineral products" has been disaggregated into "Heating fuels", "Transport fuels" and "Other refined mineral products". The latter is added to the Rest of industry commodity. The Refinery sector remains aggregated, because the production processes of the three commodities are highly integrated. The data sources used for the disaggregation are the Energy NAMEA data (Nathani et al. 2013) and the Swiss energy statistics (Swiss Federal Office of Energy 2009).
- "Crude oil" is separated from "Products of mining and quarrying". It is solely composed of imports.
- The value added row of the IOT is disaggregated into labor, capital and income taxes. Labor was calculated from data of the Federal Office of Statistics, more precisely from full time equivalent and gross monthly wage data per economic sector.
- To model insulation, an input from Rest of Industry is included in the heating nest. The total value of this input is set to 5% of total Construction demand, excluding own demand and road and infrastructure, which amounts to 1/3 of total construction (see Körber and Kaufmann 2007).

The input of insulation into each sector is distributed according to the respective sector's share in total demand for heat. This way, each sector has the same benchmark value share of insulation in its heating nest. Insulation is not modeled for the energy sectors, because their inputs of heating fuels are used mostly for industrial processes rather than for heating buildings.

3.3.2 Elasticities of substitution

The elasticities of substitution for the value added (KL) and the total value added vs. energy (KL,E) nests are particularly important for the representation of energy efficiency improvements. Table 6 lists the respective elasticities used in GENESwIS.

Table 6: GENESwIS' elasticities of substitution

Nest	Sector	2015	2025	2035
KL	Other emissions trading sectors	0.303	0.505	0.707
	All other sectors	0.319	0.745	1.170
KL,E	Rest of industry	0.296	0.691	1.805
	Other emissions trading sectors	0.312	0.728	1.144
	Electricity / gas/ mineral oil	0.102	0.204	0.306
	Food and beverages	0.180	0.359	0.539
	Transport	0.112	0.224	0.336
	Rest of services / housing	0.091	0.364	0.819

The elasticities of substitution between capital and labor (KL nest, see also Figure 3 and Figure 4) are derived from Mohler/Müller 2012. They estimate elasticities for the Swiss manufacturing industry, e.g. for Emissions trading sectors and Rest of industry. To account for differences in short-term and long-term elasticities, the elasticities of substitution are set in GENESwIS to be linearly dependent of time. As the elasticities in Mohler/Müller 2012 apply to a timeframe of 14 years, the values are used for 2025 and are doubled for 2050 (which is outside the actual model horizon). A linear approximation is fitted through these two points. It is assumed that the remaining sectors display the same elasticities as the Rest of industry sector.

The elasticities between energy and the value added nest (KL,E nest, see Figure 3 and Figure 4), are taken from Mohler/Müller 2012 for Emissions trading sectors and Rest of industry, and from Ban/Okagawa 2008 for the remaining sectors. A similar linear fit as for the KL nest elasticities is set up. As Ban/Okagawa 2008 compute their elasticities on a timeframe of 19 years, the first anchor point for the elasticities is set to 2030, doubling in 25 years.

Table 7: GENESwIS' Armington elasticities

Commodity type	
Electricity	2.8
Fossil fuels	1.9
Food and beverages	2.2
Rest of industry	2.5
Services	1.9

Source: Hertel 1997 and Burniaux/Truong 2002

3.3.3 Household data and taxes

For the two alternative household aggregations (described in section 3.1.2 and depicted in Figure 1), we use the data set which Ecoplan created for its model simulations for the 2012 report on the economic effects of Switzerland's energy strategy 2050 (Ecoplan 2012b). Ecoplan's data set is based on the Federal Statistical Office's (FSO) household budget survey (HBS) (Federal Statistical Office 2010b, 2011, 2012). The HBS data from 2007 to 2009 were pooled. The division into categories according to standard of living equally takes into consideration income and consumption expenditure and relates them to the number of people in the household on OECD's modified equivalence scale (OECD undated). The number of households in each category can vary. Thus, the living standard categories are different from income quintiles.

Since the data from the HBS do not precisely match the macro data in the IOT from 2008, a calibration process was required. To this end, Ecoplan introduced, next to the 15 regular household types in each aggregation, a *capitalist* to whom all excess capital income was assigned. In this way, around half of the total capital income was allocated to the *capitalist* (Ecoplan 2012b). As we decided to avoid Ecoplan's approach to define a capitalist household, further modifications became necessary to fit the HBS data to the model. Generally, we prioritized HBS data over totals from the IOT with the aim to minimize data modifications for channels which affect distribution between households.

When dynamic model consistency has to be guaranteed, there are limits to modifying capital income in the IOT. Thus, similar to Ecoplan, we had to allocate additional capital income to the households. Instead of creating a *capitalist*, we distributed this additional income to the households in proportion to the capital income given in the HBS data. To keep capital income tax payments constant without modifying tax rates, we had to assume that this additional capital income remains untaxed. This assumption allows for a correct representation of marginal capital taxation in the model. According to the HBS data as well as in the model, labor and capital are taxed at different rates on a household level. As our approach does not change incentives for investment and labor provision in the model, we believe that it is the economically most neutral way in which the given problems with data matching can be resolved.

The following list provides further details on the adjustments:

- **Labor income** is higher in Ecoplan's version of the HBS data than in the Swiss IOT. The discrepancy was corrected through a proportional deduction of 4% from labor income, balanced by an equal-sized correction to capital income.
- As far as taxation is concerned, most of the **social benefits** can be treated in the same way as labor income, e.g. first pillar old-age pensions. In the Ecoplan version of the HBS household data, the income category "social benefits" also contains the second pillar, which follows a different taxation scheme and can hence not simply be added to labor income. Therefore, this portion was deducted from social benefits and added to capital income. To this end, the original HBS data as provided by the Federal Office if Statistics was drawn upon. It provides information on the value of the payments by the second pillar contained in the social benefit transfers. According to this data, an average of CHF 23.98 billion were distributed from this source for the years 2006-2008. As the original HBS data does not contain the same household categories, we distributed this

amount to the different household categories using the information that is actually available in the original HBS data.[4]

- For **fossil fuels**, we prioritized the IOT data over Ecoplan's version of the HBS data to ensure consistency with NAMEA (Nathani et al. 2013) emissions data. Adjustments to household demand for fossil fuels have been applied proportionally, separately for heating and transport fuels.

We have undertaken considerable efforts to represent differences in **factor taxation** between labor and capital as well as differences between average and marginal labor tax rates for the different household categories. From Ecoplan's HBS data, only the absolute tax payment for each type of household is known, but not how this is composed in terms of labor and capital tax. Hence, data on factor taxation from other sources needs to be incorporated and prioritized over HBS data where necessary.

In a next step, this information is used to calculate the expected labor tax payment for each of the modeled household categories, also taking into account the composition of each household category[5]. As similar information is unavailable for capital taxation, we assume a flat rate of 20%, which results in a reasonable match with the HBS data on tax payments. Due to the use of different data sources, the match cannot be perfect. For most household categories, the calculated expected tax payments lead to an overestimation in comparison to the tax payments disclosed in the HBS data. For the household categories in question, a portion of the capital was deemed as tax free, such that the expected tax payment and the actual tax payment match. Importantly, the amount of capital being exempt from taxation does not exceed the capital transferred from the IOT for any category. For four out of the 30 household categories, the expected tax payment is lower than the payment given by the HBS data. In these cases, the labor tax rate is increased such that the expected and the stated tax payment match. These latter adjustments are small, such that they do not distort the progressive pattern of the labor tax in any of the six types of households by which living standard

[4] According to the HBS data, families with children do not receive any such payments (or none which are statistically significant); Couples without children receive an average of 42% of their social benefits from the second pillar pension funds, while for single households without children approximately 31% of their social benefits consist of payments from the second retirement provision pillar. From these facts, the following allocation rules were deduced: For the household classes "NoKids", the approximation of 35% of social benefits transfers was allocated to capital income, while for households with children, no changes were introduced to the social benefits. The rate for retired households was then calculated from the remaining amount to be distributed; this resulted in a second pillar share of 39%. For the income classes structured according to geographic dispersion, no apparent pattern could be found, due to a lack of information on proximity to urban areas in the original HBS data. However, the share of Social Benefits coming from the pension fund increases in income. Therefore, a base rate of 15% was defined. With the aid of the total amount to be distributed, a rate added to each income class was then calculated. Following this approach, 21.8% (lowest income class) to 48.8% (highest income class) of social benefits were transferred to capital income. Note that this pattern can be observed only for the population as a whole. Therefore, this adjustment has only been applied to the disaggregation according to domicile, but not to the disaggregation according to family type, to which no differentiation in income has been applied.

[5] Tax rates from the Federal Tax Administration are available only for single households, married couples without or with two children. Tax rates for the households in the model were calculated considering the actual composition of the household. For example: The tax rate of a household of a married couple with one child would be calculated by taking into account 50% of the married couple without children and 50% of the married couple with two children. See Annexes 7 and 8 for details on the composition of the various household categories.

categories are differentiated (Kids, NoKids, Retired, City, Agglo, Periphery). The resulting taxation pattern across the various household types can be seen in Figure 5.

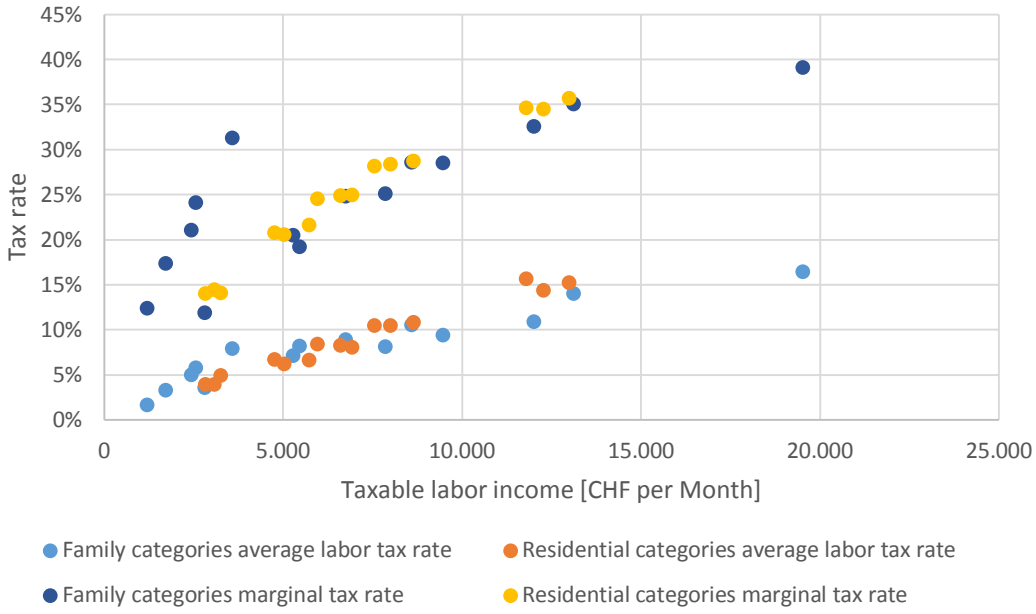


Figure 5: Average and marginal labor tax rates dependent on taxable labor income for the modeled household categories.

The average labor tax rate is calculated on the basis of net labor income. For the calculation of the marginal tax rate, the capital income declared in the HBS plus the part of the social benefits deduced for the income of the second retirement provision pillar is added to this value. The underlying assumption is that, although capital income is taxed with a different tax rate than labor income, it still increases the marginal (labor) income tax rate.

With the above, we have defined marginal and average tax rates for the thirty household groups. Now we still need to determine how rates change relative to each other. This is especially relevant for the scenario IncTax, which recycles the revenues of the CO_2 levy through changes in labor income tax rates. More generally, it is relevant for any scenario that uses the labor income tax as an equal yield mechanism, which means that labor income tax rate adjustments are used to keep public goods provision constant. This applies to all scenarios except for the scenario VAT, where revenues of the CO_2 levy are recycled through adjustments of value added tax rates.

In GENESwIS, marginal labor tax rates are applied, while endogenous transfers ensure that ultimately tax payments are in line with average tax rates. These endogenous transfers depend on labor supply, which is endogenous to the model, as well as on the difference between the average and the marginal tax rates for the respective household. When marginal tax rates change endogenously, e.g. due to recycling of CO_2 levy revenues, that difference has to become endogenous as well. To this end, we search for a function which represents the following relation:

$$\Delta(MR - AR) = f(\Delta MR)$$

MR denotes the marginal tax rate and AR the average tax rate. That is, we want to find the percentage change in the difference between marginal and average tax rates that belongs to a given change in the marginal tax rate. The resulting multiplier is used in the model to inflate the transfers,

or more precisely to deflate them, because with revenue recycling rates decrease rather than increase. The problem can be formulated in the following way:

$$\frac{MR_0 - AR_0 + \left(\frac{MR}{MR_0} - 1\right) \cdot x \cdot (MR_0 - AR_0)}{MR_0 - AR_0} = 1 + \left(\frac{MR}{MR_0} - 1\right) \cdot x = 1 + \Delta MR \cdot x$$

The subscript zero denotes initial values. The variable x corresponds to the slope of the linear log-log regression of the difference MR-AR on MR. The logarithmization of both the dependent and independent variable is necessary as the model reports and requires percentage changes. All tax rates are calculated on a net basis and are hence higher than their gross based counterparts. With the term presented above, only two known values are required: the change in marginal tax rate, ΔMR, and x, the slope coefficient that results from the linear regression.

Before the calculation, the data used is weighted with the benchmark labor income for each household category. This step mostly serves to ensure that the retired household groups with very low levels of labor income do not influence the overall result too much. The calculated slope coefficient x is 1.1944. Figure 6 illustrates the regression.

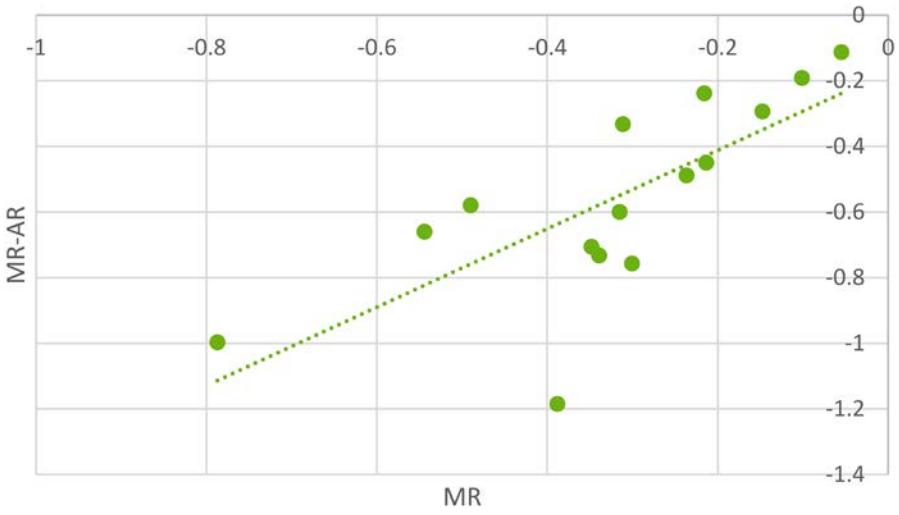


Figure 6: Regressions of the difference between the marginal and the average tax rate on the marginal tax rate for the household aggregation by family type. The data has been weighted with benchmark labor income and logarithmized.

Other taxes that are taken into account are:

- The Value Added Tax (VAT): non deductible VAT, and VAT on household consumption. Source: Nathani et al. 2013.
- Mineral Oil Tax. The mineral oil tax payments by sectors are given by Nathani et al. 2013. Mineral oil tax rates are calculated by fuel (petrol and Diesel, light heating oil, natural gas) and by group of users and levied as quantity based taxes.
- Remaining taxes in the IOT data are assigned to domestic production, investment, household and government consumption, depending on the activity specified in the IO table.

3.4 Results

3.4.1 Domestic scenarios

3.4.1.1 Abatement

To meet the dynamically tightening emission restrictions of the domestic scenarios (reaching -35.6% CO_2-eq relative to baseline in 2035, see Table 3), the tax base of the CO_2 levy is broadened to include fossil transport fuels. Despite this, the goals of these scenarios cannot be attained with current tax rates of the levy (84 CHF/tCO_2). Figure 7 displays the time path of tax rates which are compatible with the objectives for the respective time periods. The tax rates increase from about 230 CHF/tCO_2 in 2020 to about 670 CHF/tCO_2 with predominantly negligible differences between the revenue recycling variants. For the different lump-sum recycling variants, the tax rates in 2035 vary between 669 and 671 CHF/tCO_2. The superior macroeconomic performance of tax recycling variants (scenarios IncTax and VAT) leads to slightly higher tax rates of the CO_2 levy required to meet the targets (677 and 675 CHF/tCO_2 respectively).

Figure 7: Rate of the CO_2 levy in CHF_{2008} / t CO_2

These numbers, as any other quantitative computable general equilibrium model result, should not be interpreted as a forecast. In the past, technological and macroeconomic surprises have often ridiculed such numbers, certainly over a twenty-year time frame. With the upcoming commercial breakthrough of electromobility and other ongoing technological advances, affirming such numbers is even more presumptuous today than some years ago. In contrast to many other CGE models, GENESwIS uses dynamic elasticities of substitution for key energy related nests (see Table 6). Despite

this, the elasticities could reflect past relationships of substitution more than future ones. Thus, rather than predicting, we make an effort to investigate economic effects and their relative importance in a general equilibrium setting with empirical data.[6]

In this spirit, the main implication of Figure 7 is that ambitious levy-based greenhouse gas abatement requires a broad tax base when high tax rates are to be avoided. Without including transport fuels in the tax base, the abatement objectives cannot be attained. Even then, the tax base, which excludes fuel related emissions that are regulated under the emissions trading system (ETS), covers less than two thirds of total GHG emissions in 2015. This share declines over time in the scenarios, thus implicating rather high tax rates to attain the objectives in 2035.

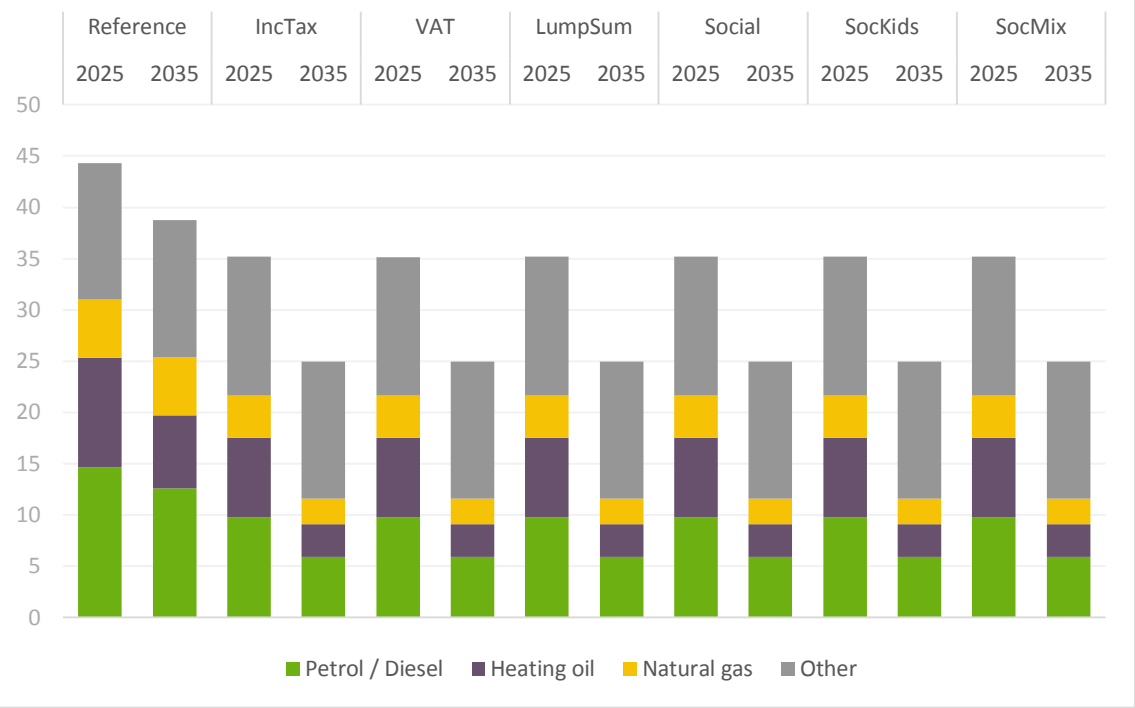


Figure 8: Composition of greenhouse gas emissions (Mt CO_2-eq)

This issue also leaves its traces in Figure 8, which shows the composition of greenhouse gas emissions. With the simulated policies, *Other* emissions remain largely unabated, turning the 2035 objective into a real challenge for fuel related emissions. Again, it becomes apparent that further exemptions in addition to the ETS, such as a prolonged nonconsideration of transport fuels, make the

[6] The rates of the uniform CO_2 levy which are suggested by different CGE studies for Switzerland are generally within the same order of magnitude for similar levels of abatement. Simplistic direct comparisons between numbers from different studies are not particularly insightful, especially when the studies have been published in different years. As baseline emissions change over time (for example, due to higher demographic projections), the effort for reaching a given emissions path changes as well. Also, the later the study, the shorter the remaining adjustment period up to a particular target year. Furthermore, even with similar parametrizations, differing model structures (especially with respect to sector aggregations and CES nestings) imply that different models produce somewhat different quantitative results. This is a prevalent and even desired characteristic of model-based economic research.

objective of a 35.6% reduction of total greenhouse gases unattainable, at least when climate mitigation relies mainly on the CO_2 levy and on the ETS. In one way or another, emissions from other sources than heat generation will have to contribute when abatement is meant to be ambitious.

Emission reductions relative to the reference scenario are especially large for heating oil, with natural gas and electricity as available substitutes. Emissions from transport are approximately halved in 2035, while electricity demand (not in the figure) increases by 10.6%. Differences between revenue recycling variants are again negligible.

3.4.1.2 Macroeconomic impacts

With regard to overall economic performance of the simulated policy reforms, we have not found a so-called double dividend, i.e. welfare in the model decreases by about 1% in 2035. The definition of welfare used in the model entails consumption, leisure and preferences for investment. It does, however, neither include benefits of reduced climate risks nor ancillary benefits of mitigation measures such as lower health costs under reduced air pollution. It can be inferred from estimates of ancillary benefits in Ecoplan 2012a and 2012b that they considerably narrow the overall welfare loss for our simulated scenarios. Furthermore, even double dividends are well possible in the Swiss context, provided however that tax rates of the CO_2 levy are much lower than in the scenarios simulated here.

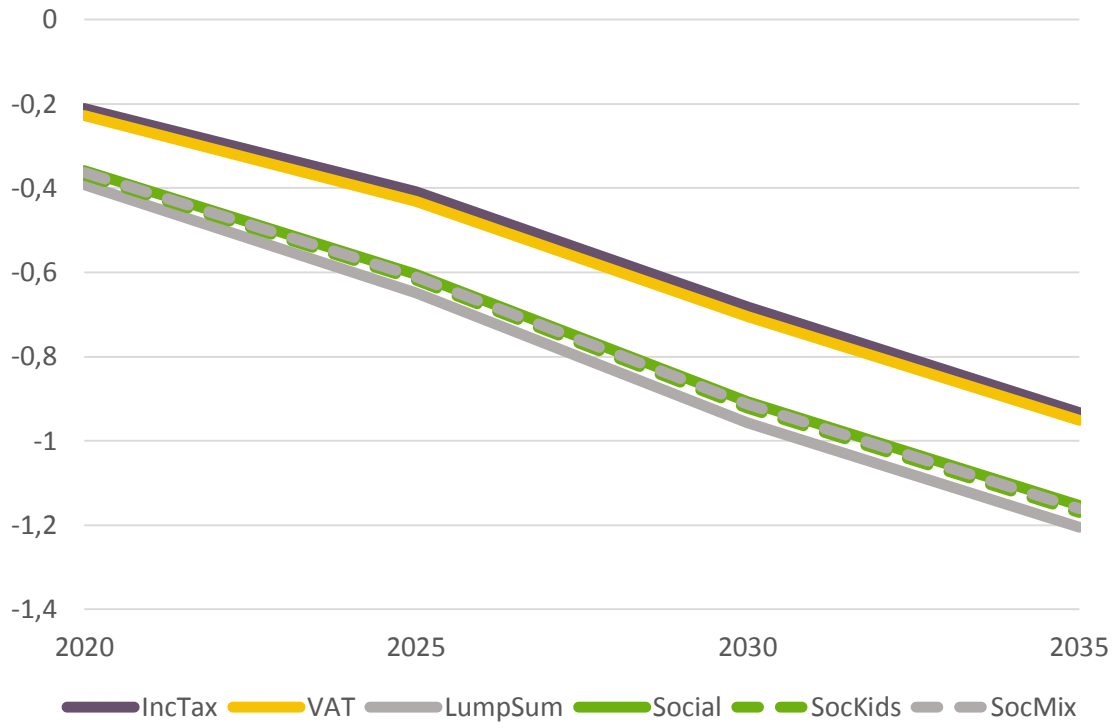


Figure 9: Aggregate welfare impact of domestic policy scenarios relative to the reference case (in %)

There are noticeable, although modest differences between the revenue recycling variants. The two variants which reduce existing taxes (income tax or value added tax) perform better in terms of aggregate welfare than pure lump-sum recycling. The former variants significantly reduce the excess burden of existing taxes, while for the latter variants this is not the case. It has to be added, however, that the aggregate welfare measure displayed here does not evaluate the social progressiveness or

regressiveness of the reform. In welfare theory, different aggregations of individual welfare indicators are possible, depending on the social preferences assumed. Thus, for welfare measures which entail considerable inequality aversion, the order of the scenarios will be reversed. Instead of presenting alternative welfare measures, which tend to remain somewhat crude and arbitrary, we present distributional impacts in sub-chapter 3.4.1.3. This allows the reader to evaluate the impacts according to own social preferences.

According to our simulations, income tax recycling is slightly more successful in reducing excess burden than value added tax recycling. Typically, the relative performance of these two variants depends on model specifications, more precisely on factor mobility assumptions and the modeling of income taxes. Although GENESwIS does not consider international factor mobility, we do capture the higher excess burden of income taxes. This is due to the elaborate modeling of labor taxes: For each household category, we tax labor according to the applicable marginal tax rate. This ensures that the full distortionary effect of income taxes is taken into account. At the same time, virtual lump-sum transfers ensure that actual tax payments, which reflect average tax rates, match with the data. When marginal tax rates change under income tax recycling, we adjust also the virtual transfers. This is necessary to correctly represent the empirical relationship between marginal and average tax rates. The latter do also change, but less than marginal tax rates.[7] Overall, the appropriate modeling of marginal taxation is an important determinant for the economic impact of income taxes and income tax recycling. It importantly affects distributional impacts as well. After all, differences in economic efficiency between income tax recycling and value added tax recycling are small. Thus, policy choices can be based on distributional properties and on considerations of practicality for tax authorities and federal budgetary planning. Differences in aggregate economic efficiency between lump-sum recycling variants are equally slim, which allows for focusing on distributional impacts when choosing among these variants.

Looking at the consumption of goods and services only (see Figure 10), we find similar patterns as for aggregate welfare, although the magnitude of the changes is larger. For the lump-sum recycling variants, declining real wages increase the demand for leisure and reduce labor supply and thus the real income which is available for conventional consumption (see Figure 11). Hence, the decrease is especially pronounced for these scenarios. In turn, the VAT recycling variant is a notable exception: Although it is slightly inferior to income tax recycling in terms of aggregate welfare, it is clearly the top variant in terms of consumption of goods and services. Reduced VAT rates increase the attractiveness of consumption relative to investment (also see the investment graph in Figure 11), which – at least in the medium run – increases consumption. The shapes of the consumption and investment curves foreshadow that the curves for the scenarios IncTax and VAT could intersect in the very long run.

In Figure 11, real return to capital slightly decreases for all recycling variants. This does, however, not imply that investment would be lower for all variants. In the lump-sum recycling variants, for example, relative factor prices shift in favor of capital remuneration. The resulting factor substitution keeps investment levels roughly constant, despite an overall economic contraction.

[7] For further information, see section 3.3.3.

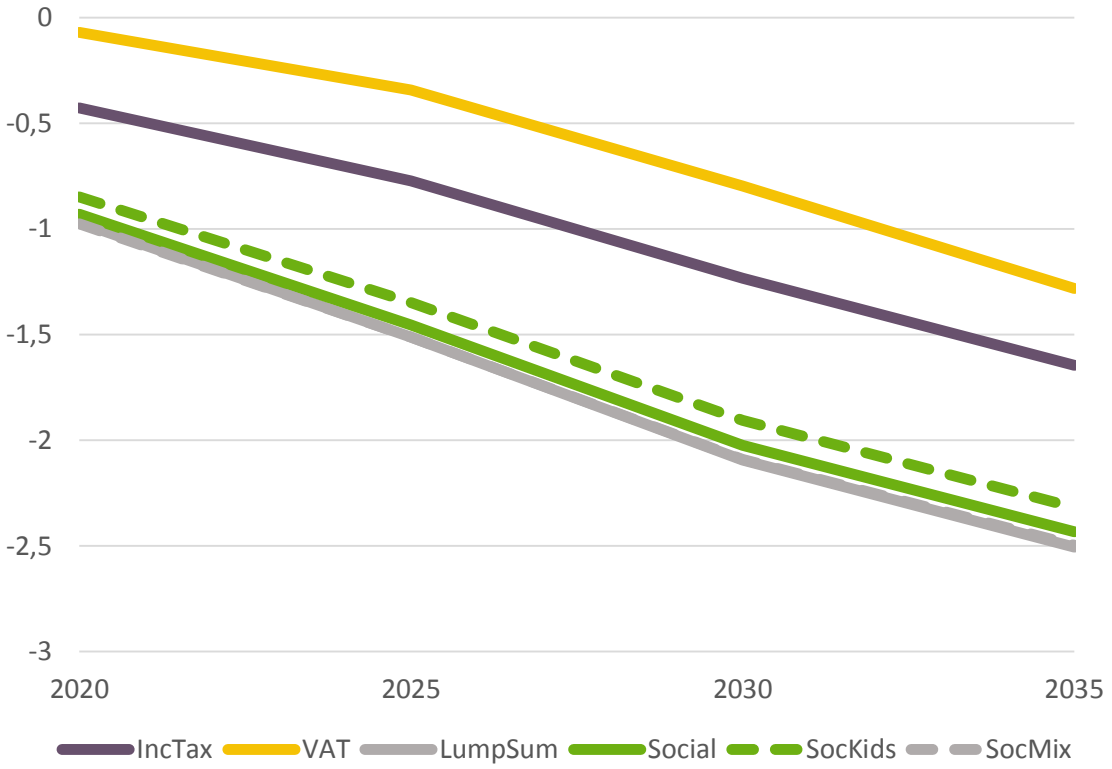


Figure 10: Consumption for domestic policy scenarios relative to the reference case (in %)

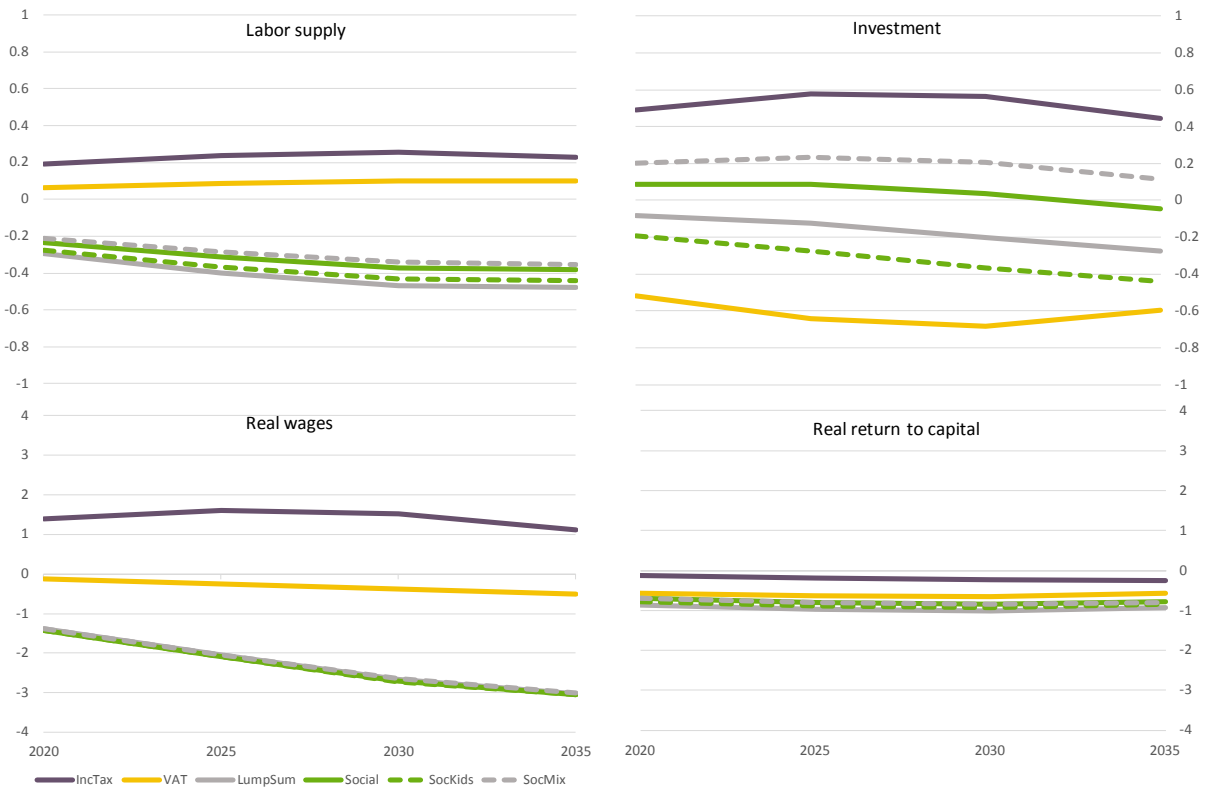


Figure 11: Labor supply, investment, wages and return to capital for domestic policy scenarios relative to the reference case (in %)

Labor supply increases under the two tax recycling scenarios, especially, of course, when labor taxes are reduced, increasing real wages by more than 1%. The simulated percentage changes of up to +0.25% are, however, not a big boost in labor supply. Under the lump-sum revenue recycling variants, labor supply decreases. This is due to lower real wages, which reflect the general economic contraction. In GENESwIS, the shifts of labor supply and demand are the result of deliberate decisions of the agents. Changes in labor quantities in the model are thus different from impacts on involuntary unemployment, although some relationship between the two may exist.

3.4.1.3 Distributional impacts

Before we take a look at the overall distributional impacts of the domestic policy scenarios, let us draw the attention to Figure 12, which shows the per capita amounts that are recycled to the different household groups in 2035. In the scenarios with revenue recycling via the income tax (IncTax), and via the value-added tax (VAT), the amount of taxes saved increases in the living standard.[8] As retired people exhibit little labor income compared to the other household groups, they are barely considered by recycling measures in the IncTax scenario, given that we merely lower marginal labor tax rates in this scenario.

In the lump sum case, every person is by definition allocated the same amount. In the scenario with targeted social policy, the definition of the recycling ensures that funds are distributed among the bottom three categories of standard of living in each of the aggregations. Additionally, in the scenario with child benefits (SocKids), half of the total levied tax funds are redistributed as lump sum transfers per child. The SocMix scenario, in addition to the targeted social refunds and the child benefits also allocates transfers to retired people. Still, in these two cases, the pattern of the poorer households receiving higher compensation clearly remains. For further information on the recycling schemes, please consult chapter 2.4.

It is important to note that in the figures of this sub-chapter, each bar represents impacts for the respective household group, in CHF per capita in Figure 12 and in percentage changes relative to the reference case in Figure 13 and Figure 14. Household groups differ in many respects, especially in

- the number of households per household group,
- the number of family members per household,
- income, consumption and welfare levels.

For example, within the highest standard of living category, more than seven times as many people live in *NoKids* households than in *Retired* households. For another example, per capita income in these rich *Retired* households is more than eleven times the per capita income in the poorest category of *Kids* households (see Annex 7). As a consequence, it would be misleading to, consciously or subconsciously, add up the bars for the different household groups to gain a picture of aggregate impacts. The latter have been presented in sub-chapter 3.4.1.2.

With this in mind, we move on to the representation of distributional impacts of the domestic policy scenarios. We mostly analyze welfare impacts for the different household groups in 2035 (see Figure

[8] The amounts displayed for these two scenarios are approximations based on benchmark year (2008) weightings and, in the case of the IncTax scenario, reference marginal tax rates.

13). Figure 14 presents the same indicator for 2025. Due to the lower tax rate of the CO_2 levy, effects are less pronounced in 2025 than in 2035, despite the higher tax base for the CO_2 levy due to the lower abatement requirement. Also, as the overall welfare indicator in 2025 is superior to 2035 (see Figure 9), a few household groups are above the break-even line in 2025, but below it in 2035 (*Kids2* households in the scenarios *LumpSum* and *SocMix*, *Kids3* households in the scenario *SocKids*). Other than this, distributional impacts in 2025 and 2035 follow the same patterns in the different domestic policy scenarios. It might be helpful to reiterate at this point that the presented welfare measures do neither include benefits of reduced climate risks nor ancillary benefits of mitigation measures such as lower health costs under reduced air pollution.

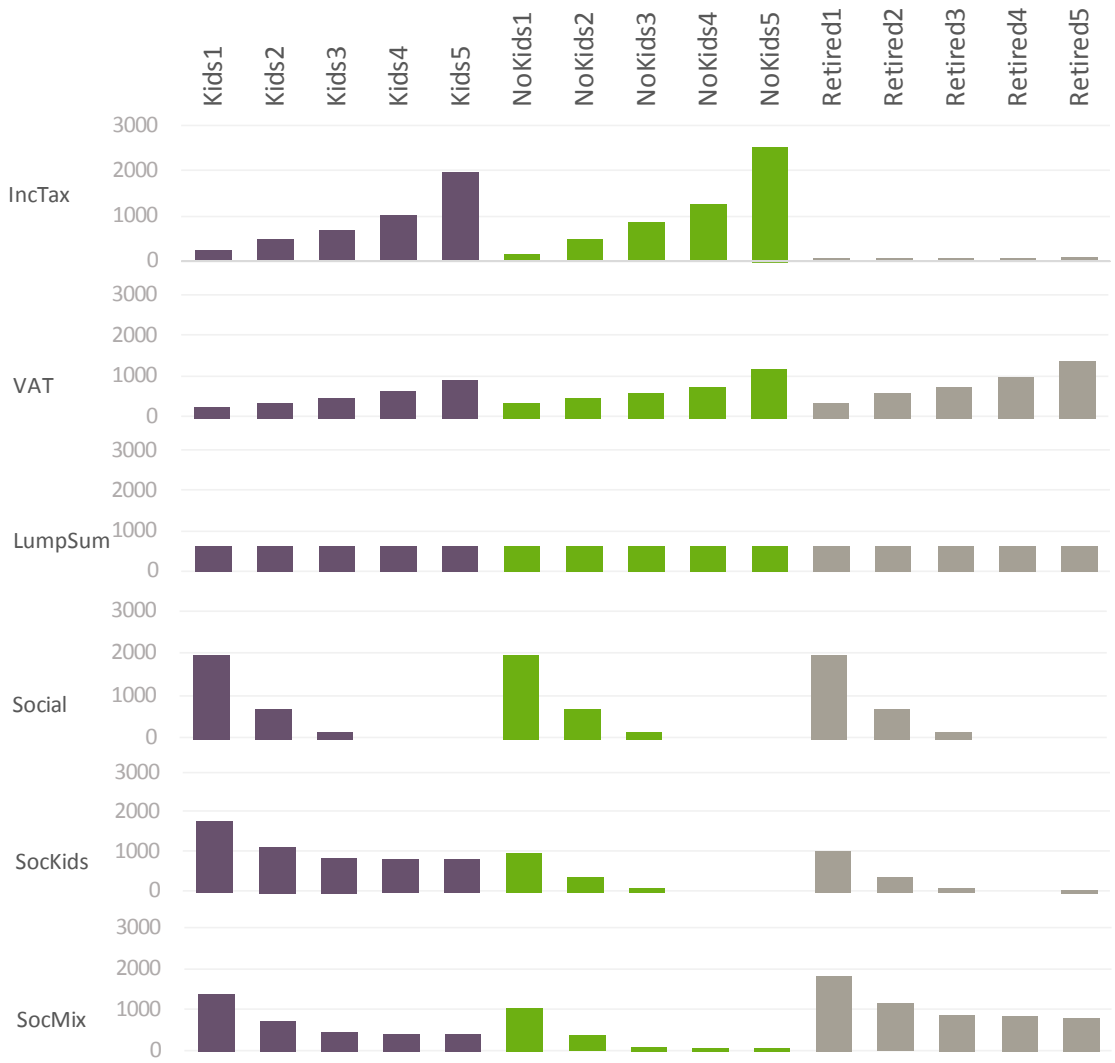


Figure 12: Revenue recycling per capita 2035 (in CHF_{2008})

With recycling through lower labor taxes (scenario IncTax), the simulated reform of the CO_2 levy becomes regressive for family households. This is different for retired households who are hardly affected by changes in labor taxes: Due to high savings rates and particularly low expenditures for transport fuels, they are hardly affected by the reformed CO_2 levy (which includes CO_2 pricing in transport) either.

Figure 13: Welfare changes relative to the reference scenario in 2035 (in %)

With recycling through lower value added taxes (scenario VAT), the reform becomes somewhat less regressive, simply because VAT rates for the same good are independent of income. Overall, changes in VAT rates do not have large distributional consequences. This is because of two opposing effects:

- On the one hand, rich households have higher savings rates than low income households. The larger consumption share of low income households alone would imply that lowering VAT rates has a progressive influence on distribution.
- On the other hand, there is a lower VAT rate for goods that cover daily needs (2.5% instead of 8%). With proportional VAT rate reductions, as simulated here, those who purchase more “8% goods” benefit more from the recycling. A more socially oriented reform could concentrate on the reduced rate. In this case, eliminating the reduced rate would make sense, given that this would save the costs of administrating this part of the tax while requiring less than the total amounts that can be recycled.

Considering the above, regressive effects of the magnitude shown in Figure 13 for the scenario VAT are not an implication of the recycling, but mostly of the CO_2 levy itself. Considering further that Switzerland hardly exhibits energy intensive industries, the regressiveness of the CO_2 levy is mainly a consequence of differences in the composition of expenditure. This becomes apparent when we consult the household data, more precisely the shares of expenditure for fuels in total household income. Compared to households in the highest category of standard of living, this share is about twofold in the lowest category. The difference is especially pronounced for households with children. For them, the multiplier is 2.34 (1.72 for households without children). Furthermore, the households with children in the lowest category exhibit the highest share of all households in the aggregation (3.6%). This contrasts to a share of only 2.2% for retired households in the same category.

Figure 14: Welfare changes relative to the reference scenario in 2025 (in %)

Thus, recycling needs to be progressive for the reform not to be regressive. This condition is satisfied by all the simulated lump-sum scenarios (LumpSum, Social, SocKids, SocMix). Transferring to households equal amounts per capita is already a highly progressive recycling variant, given that per capita

income for the richest household (Retired5) is more than eleven times that for the poorest household (Kids1). Indeed, the scenario LumpSum is clearly progressive overall, i.e. despite the regressive characteristics of the CO_2 levy. The results indicate that using only a part of the revenue of the CO_2 levy suffices to neutralize potentially undesired distributional impacts. With a view to such a neutrality objective, the current recycling scheme of the CO_2 levy – with a lump-sum recycling share of about two thirds – seems suitable.

The welfare results for the other three lump-sum scenarios (Social, SocKids, SocMix) illustrate that about any social objective can be pursued by tailoring lump-sum transfers to specific groups. This is administratively simple for children and retired persons (through child benefits and first pillar pensions). Effective targeting to low income groups is somewhat more difficult. One possible instrument is the subsidy for health insurance premiums, although it is granted also to many middle class households. In the scenario *Social*, we thus assume that only 70% of the transfers go to households in the lowest income category, 25% to the second lowest, and 5% to the third lowest. The main conclusion that can be drawn from the simulation results of the different lump-sum scenarios is that using even a small share of the CO_2 levy revenues for transfers to low income households and families with children is enough to solve the regressiveness issue.

When CGE models, in contrast to the current version of GENESwIS, do not differentiate between households and thus report only for one representative agent per country, they have severe difficulties in investigating distributional effects. Then, the only way to do this is to look at impacts on functional income distribution by analyzing relative factor price changes. As rich households have a higher savings rate than poor households, it could be assumed that a reform might be regressive when relative factor prices change in favor of capital remuneration.

Following this argument would, in our simulations, misleadingly reverse the conclusions on distributional impacts. As can be seen in Figure 11, net factor prices change in favor of labor in the scenario with recycling through the labor tax (IncTax) and in favor of capital in the case of lump-sum recycling (LumpSum, Social, SocKids, SocMix). With disaggregated households it becomes apparent, however, that the IncTax scenario's reform is clearly regressive, while the reforms with lump-sum recycling are clearly progressive. This confirms the notion that single representative agent CGE models are unfit to investigate distributional issues. For this particular study, the two main reasons are the following:

- Differentiated effects of lump-sum recycling cannot be taken into account.
- Abstracting from revenue recycling, differences in expenditure composition between households are the main driver for the regressiveness of the CO_2 levy. However, these cannot be captured without a disaggregation of households.

3.4.2 Scenarios with recycling through imported carbon offsets

3.4.2.1 Abatement

By definition, total abatement is larger in the Abate than in the Offsets scenario. In the Offsets scenario, total abatement is defined by the domestic targets, and imported offsets count toward the national target. In the Abate scenario, the same targets are attained without imported carbon offsets, and the offsets purchased with the revenues of the CO_2 levy are used for additional abatement. As the exogenously assumed prices for imported offsets are much lower than the rate of the CO_2 levy, this additional abatement is very sizable (see Figure 15).

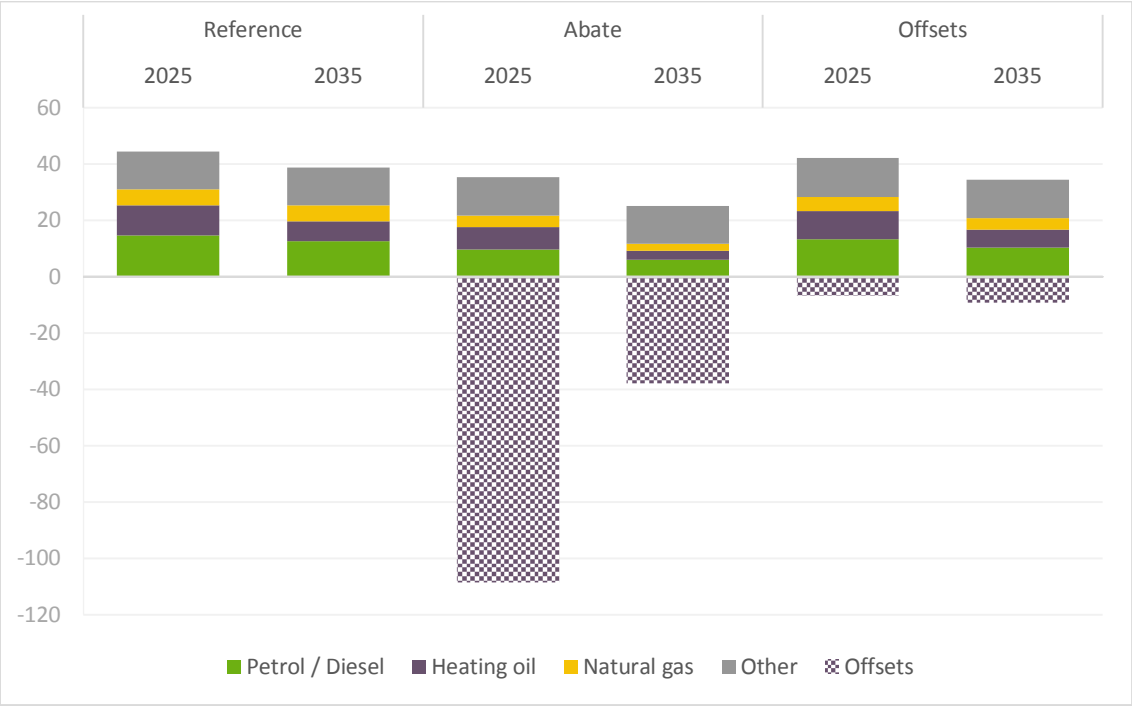


Figure 15: Composition of emissions (in Mt CO_2-eq), comparison between the two scenarios Abate and Offsets

The revenues in the Abate scenarios are high enough to offset 2025 emissions several times and to overcompensate total Swiss GHG emissions in 2035. In the latter year, purchased emission reductions are almost equal to reference emissions. It is understood that the displayed quantities highly depend on the assumed prices for imported offsets. With perpetual 10% price increases per year on current prices for European allowances (see chapter 2.2), the assumed prices are more likely a little too high than too low, which indicates that the purchased abatement could even be higher than shown here.

The purchased emissions reduction in the Abate scenario is smaller in 2035 than in 2025 for two reasons:

- Due to tighter emission targets, the tax base of the CO_2 levy is smaller.
- Although the rate of the CO_2 levy increases between 2025 and 2035, prices of foreign offsets rise much faster, by 10% per year according to the exogenous assumptions.

The Offsets scenario can better be appreciated when compared to a domestic policy scenario with the same targets for total abatement (see Figure 16 for a comparison with the domestic policy scenario LumpSum). Although total emissions are the same by definition, the abatement is entirely domestic in the scenario LumpSum, but predominantly takes place abroad in the scenario Offsets. The scenario is constructed such that offsets are only purchased when this is cheaper than domestic abatement. This effectively sets the tax rate of the CO_2 levy at the price level of the international offsets. The results thus give an indication of the Swiss abatement which can be achieved at marginal costs that are equal to international prices (assumed at 84 CHF/tCO_2-eq in 2035). Domestic abatement in 2035 is 11.3% relative to the reference scenario, which is a little less than a third of the total abatement.

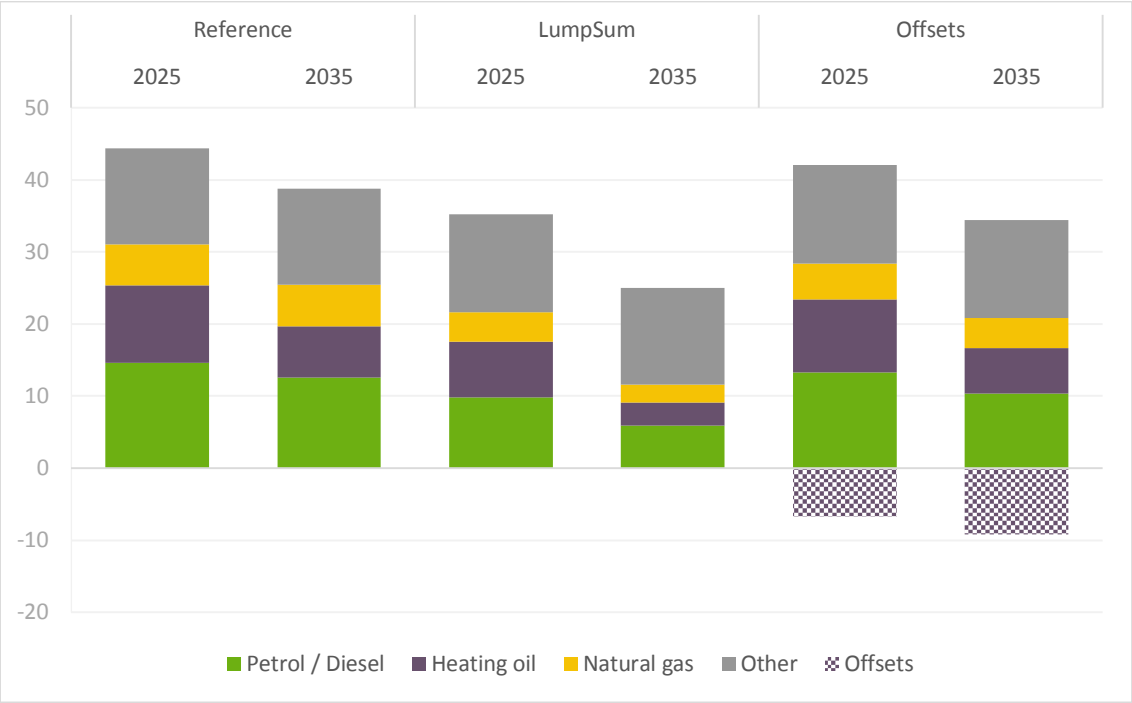


Figure 16: Composition of emissions (in Mt CO_2-eq), comparison between the Offsets scenario and a domestic policy scenario

3.4.2.2 Macroeconomic impacts

The Offsets scenario performs better than the domestic policy scenarios in terms of aggregate welfare (see Figure 17 for the Offsets scenario in comparison with Figure 9). However, the difference is in the order of magnitude of ancillary benefits of domestic abatement, which are not taken into account in the reported welfare measure.

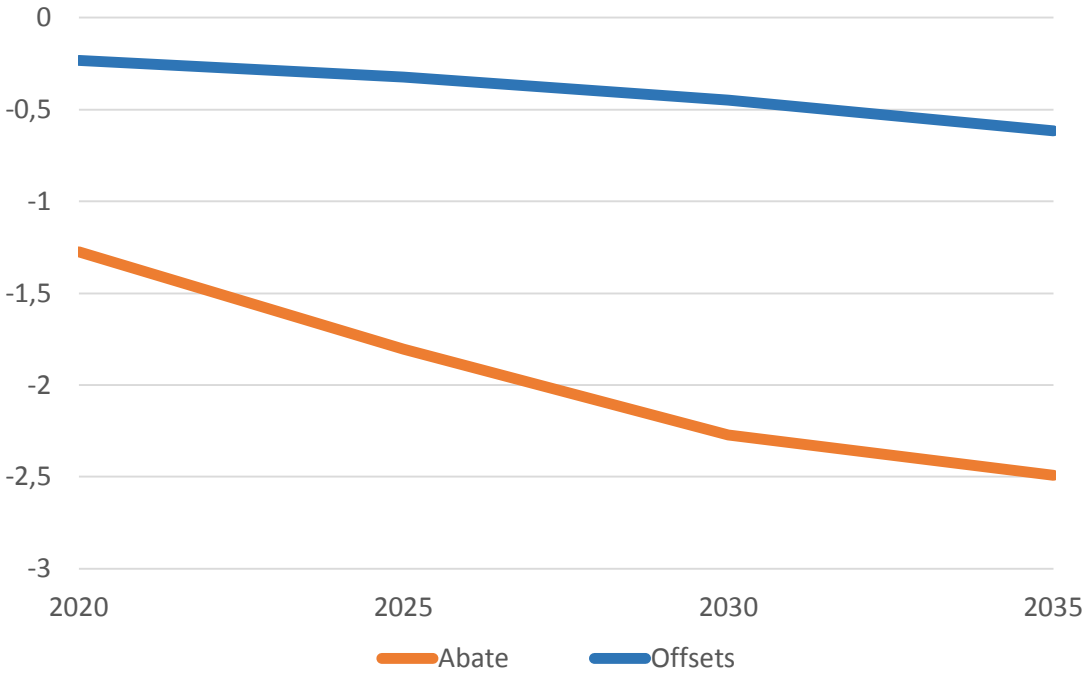


Figure 17: Aggregate welfare impact of imported offsets scenarios relative to the reference case (in %)

The superiority of the Offsets scenario in the model is by construction: In contrast to the domestic policy scenarios, foreign emission allowances, which are available relatively cheaply, may be used toward the national target, and Switzerland minimizes the cost of abatement by adjusting the choice between foreign and domestic abatement.

It has been demonstrated in the previous section that the Abate scenario with additional abatement via the purchase of foreign offsets is very effective in terms of total greenhouse gas reduction, offsetting much more than total Swiss emissions. Yet, this scenario has detrimental effects on aggregate welfare (see Figure 17), because it fails to reinsert the revenues of the CO_2 levy into the Swiss economy. This indicates that, because of the environmental effectiveness, purchasing foreign offsets for additional abatement could be a recycling option for a part of rather than for the entire revenues from the CO_2 levy.

3.4.2.3 Distributional impacts

The welfare impacts of the Abate scenario on households mirror the severe macroeconomic consequences (see Figure 18 for 2035 and Figure 19 for 2025). This is less true for retired households, who receive a much higher share of their income through transfers. This income component is paid independently of macroeconomic performance, at least according to model assumptions.

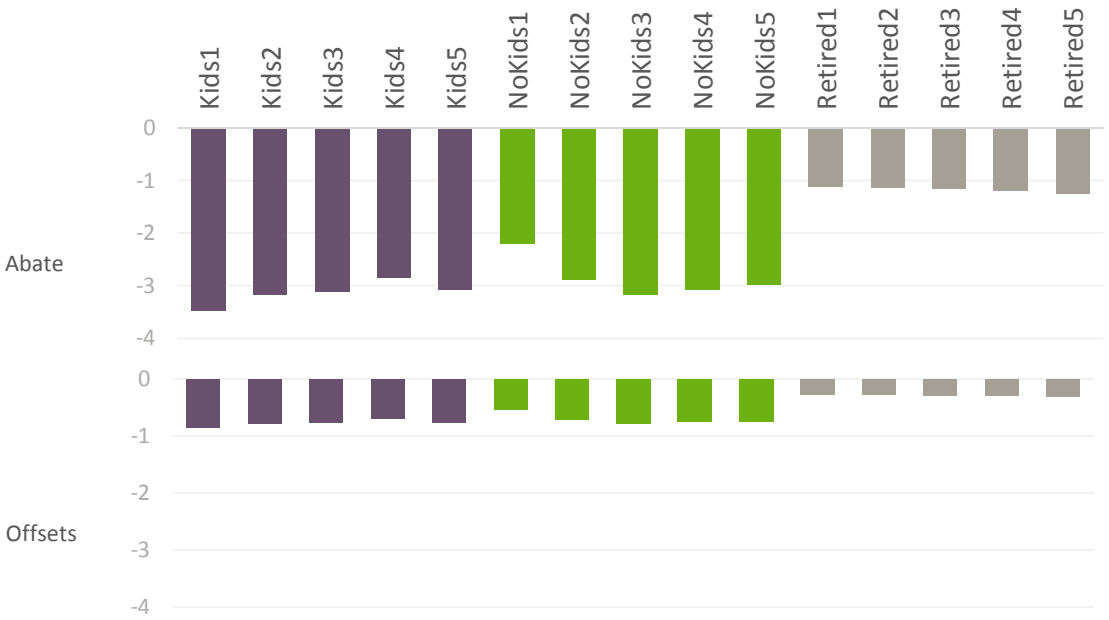


Figure 18: Welfare changes relative to the reference scenario in 2035 (in %)

The Abate scenario could be seen as part of a decomposition exercise, because for the national economy it is identical to a CO_2 levy without recycling. Interpreting the results as the true impact of the CO_2 levy would however be misleading. The impacts are dominated by the macroeconomic contraction which is caused by the failure to reinsert the revenues into the economy. With a high income share of transfers for poor and retired households, this hits rich families more than others. The resulting picture is thus less regressive than for a CO_2 levy with a hypothetical recycling which would be neutral with respect to distribution. Also, the overall decline in welfare is much higher due to large income effects, which are related to the domestic vanishing of the revenues.

In face of these limitations, we can perfectly use the results in Figure 18 and Figure 19 to study the distributional consequences of the Abate scenario. Regressiveness of the tax concerns *Kids* house-

holds only. Even for them, the differences between categories of standard of living are not very large. However, high negative impacts on families, especially on poor families with children, are clearly an issue in this scenario, which could be solved using a part of the revenues for lump-sum transfers.

For the offsets scenario, the impacts are much less pronounced, but show similar patterns as for the Abate scenario.

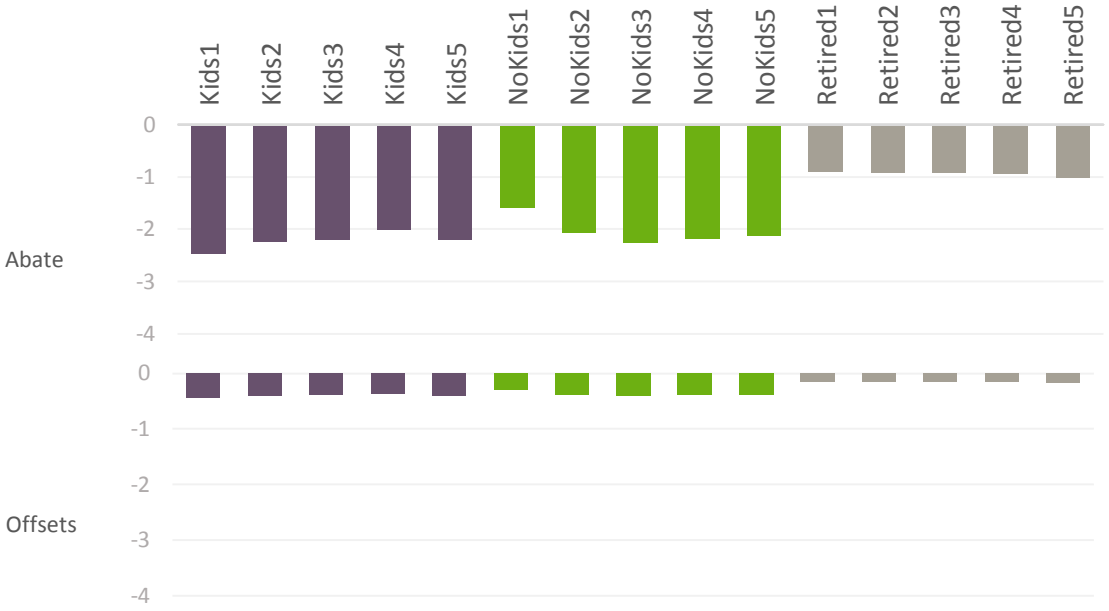


Figure 19: Welfare changes relative to the reference scenario in 2025 (in %)

Figure 19 shows the welfare changes in 2025. Compared to 2035, the impacts are smaller. This is a direct consequence of the lower CO_2 prices. The relative CO_2 price increase between 2025 and 2035 is higher for international carbon offsets than for the domestic CO_2 levy. This is reflected in the relative welfare changes, i.e. the percentage increase of welfare losses between 2025 and 2035 is higher in the scenario Offsets than in the scenario Abate.

The currently low prices for international offsets make it tempting to use imported abatement instead of domestic abatement. With the assumed prices, a trajectory with a low, but increasing share of domestic abatement is attractive in the model. However, two aspects need to be considered:

- Although an avoided ton of CO_2 has the same effect on atmospheric CO_2 concentrations regardless of the country of abatement, in climate policy domestic abatement is usually valued as the more important contribution. This may be a repercussion of the mediocre functioning of many international carbon markets as yet. It reflects as well the notion that only when all countries also contribute domestically, the necessary emissions reduction to comply with the so-called *below 2 degree goal* can ultimately be reached.
- Once international carbon prices rise, it is not a simple endeavor to jump-start an aspiring domestic climate policy. There are considerable time lags in all phases of the energy transition, e.g. in policy design, political decision-making, pilot phases and implementation, as well as capital replacement cycles.

3.4.3 International crisis scenarios

3.4.3.1 Abatement

Increasing global fossil fuel prices by 50% is an (involuntary) CO_2 abatement program. In 2025, the final year of the assumed crisis period, Swiss greenhouse gas emissions are 7% lower than in the reference case (see Figure 20). The "abatement program" is, however, a temporary one once that fossil fuel prices fall again. In 2035, GHG abatement relative to the reference case is only 0.5%. This picture may be overly pessimistic, because the model does not distinguish between different types of energy capital and thus underestimates the persisting effects of energy change.

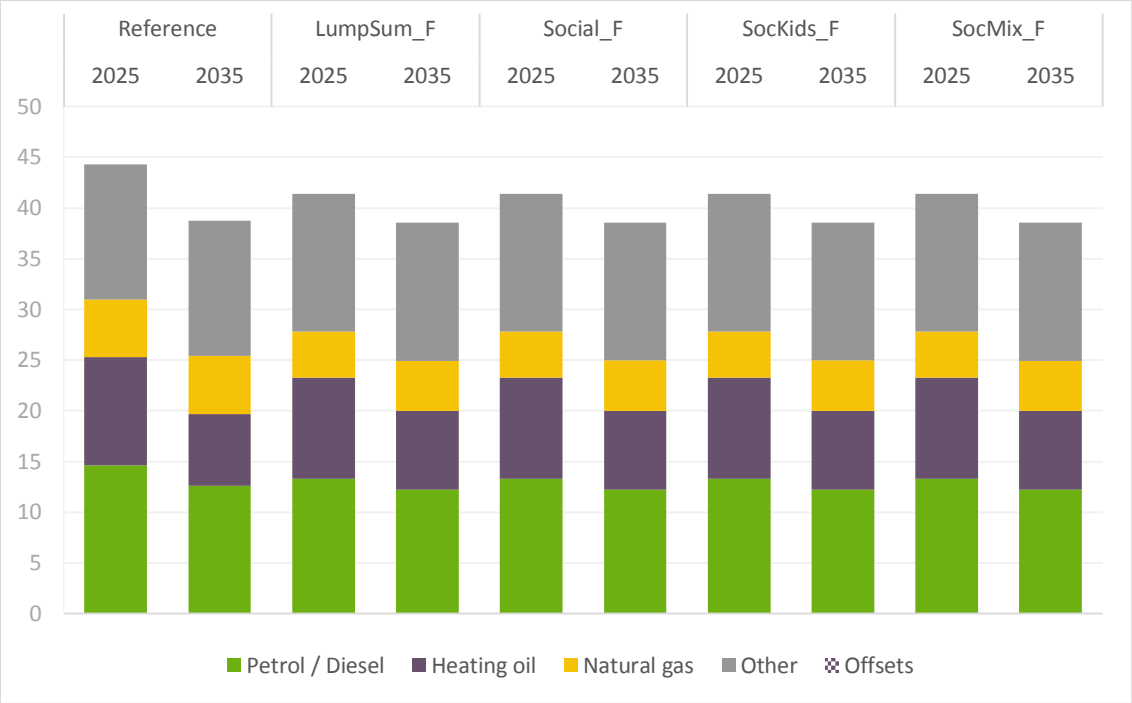


Figure 20: Composition of greenhouse gas emissions (Mt CO_2-eq)

In any case, even a 7% GHG abatement would not be enough to get anywhere near the emission reductions that Switzerland has pledged at UNFCCC COP21 in Paris. High global fuel prices might help to comply with climate policy goals, but even this is uncertain: When high crude oil prices are reported in the media, and these negatively affect the economy, it is usually not the best time for announcing ambitious climate policy.

A disproportionate share of the abatement in 2025 originates from the decline in demand for natural gas, which is about 20% relative to the reference case. The reason for this is that, while crude oil has to be transported, refined and distributed, natural gas only needs to be transported and distributed. Thus, the impact of a 50% price increase for the primary energy carrier on prices of the final energy good is higher (see Figure 21). This change of relative prices to the disadvantage of natural gas triggers, relative to the reference case, substitution processes away from natural gas. Or rather: It slows down the substitution into natural gas which is observed in the reference case. This influence on substitution processes is unfortunate for climate policy, because natural gas has the lowest CO_2 coefficient among the fossil energy carriers.

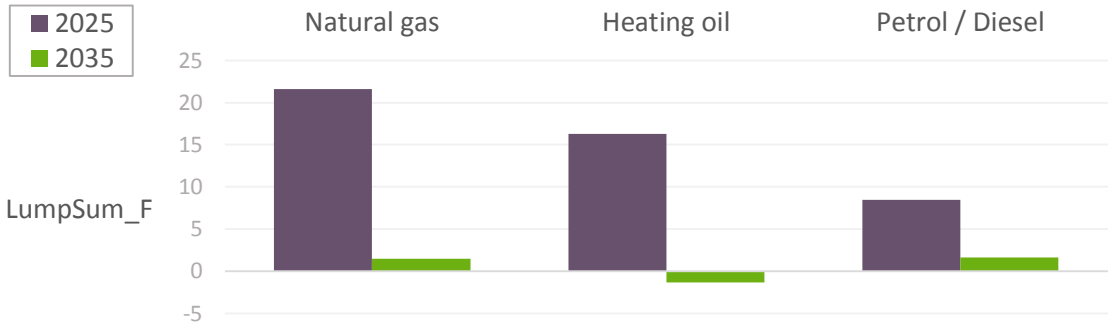


Figure 21: Net fuel prices in the international crisis scenario LumpSum_F relative to the reference case (in%)

All of the above (low abatement achieved, temporary nature of the abatement, undesired direction of substitution between fossil energy carriers) indicates that temporarily surging global fossil fuel prices cannot replace a well-designed and target oriented climate policy.

3.4.3.2 Macroeconomic impacts

Intertemporally, the international crisis scenarios exhibit a behavior that opposes that of the other scenarios. The losses in aggregate welfare are most pronounced in the periods 2020 and 2025, when high fossil fuel import prices are assumed (see Figure 22). The welfare costs in these periods are higher than in the domestic scenarios, at much lower abatement (see Figure 9 for comparison). This is, of course, a direct consequence of the deteriorated terms of trade which are inflicted on Switzerland via the global markets. Hence, we cannot *choose* between a domestic policy scenario and an international crisis scenario. We can, however, reduce dependence on fossil fuels and avoid a part of the terms of trade deterioration through carbon taxation.

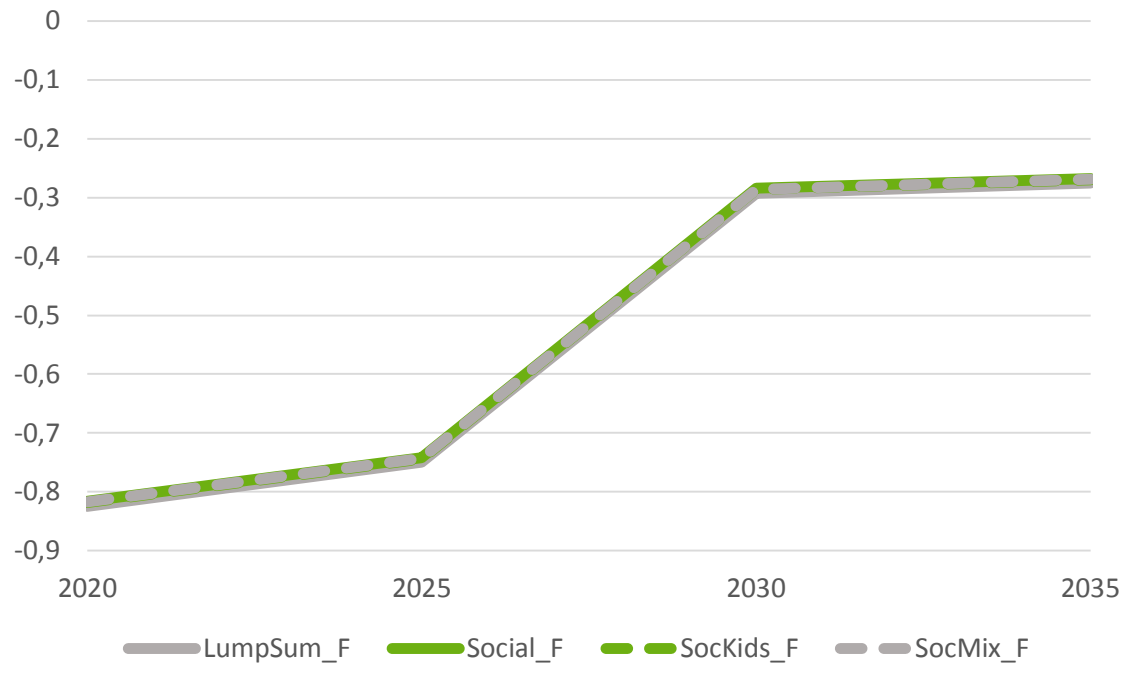


Figure 22: Aggregate welfare impacts of the international crisis scenarios relative to the reference case (in %)

A part of the detrimental macroeconomic effect of the international crisis scenarios persist until 2035, because the weakened economic growth in 2020/25 reduces investment and thus future consumption (see Figure 23 and Figure 24). With a decrease in labor supply, and thus an increase in leisure, the impact on consumption of goods and services is again larger than the decline for aggregate welfare as a whole. Labor supply is, however, not very much affected: Relative to the reference case, the decrease never exceeds 0.2%. The larger impact on investment may partly be explained by the fact that capital intensive industries tend to have higher fuel costs.

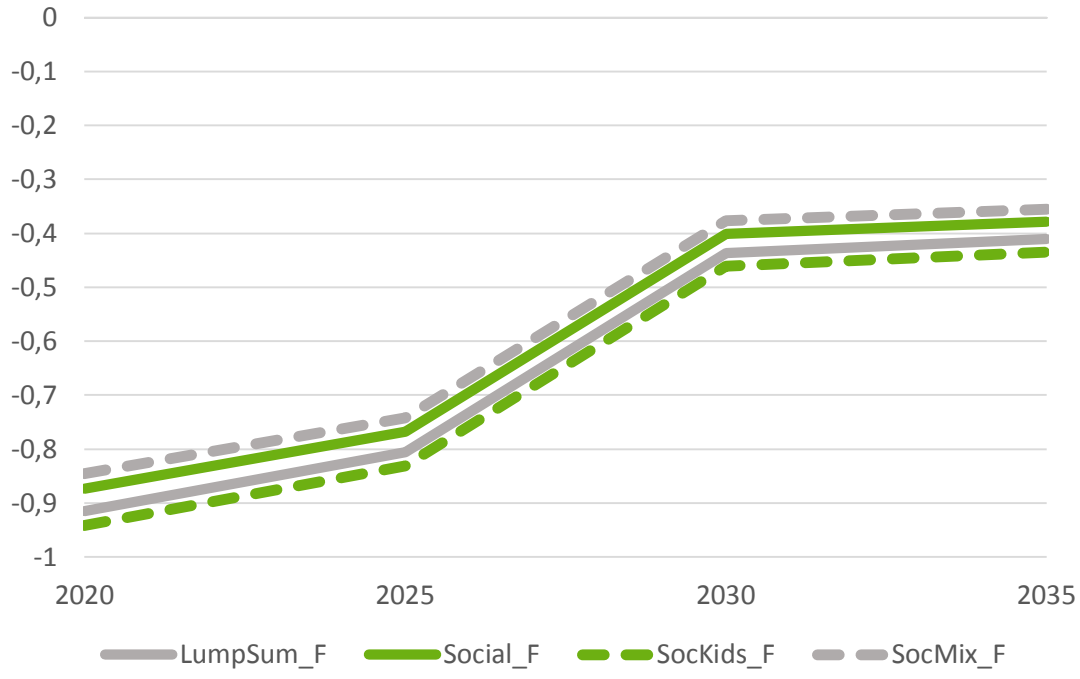


Figure 23: Investment relative to the reference case (in %)

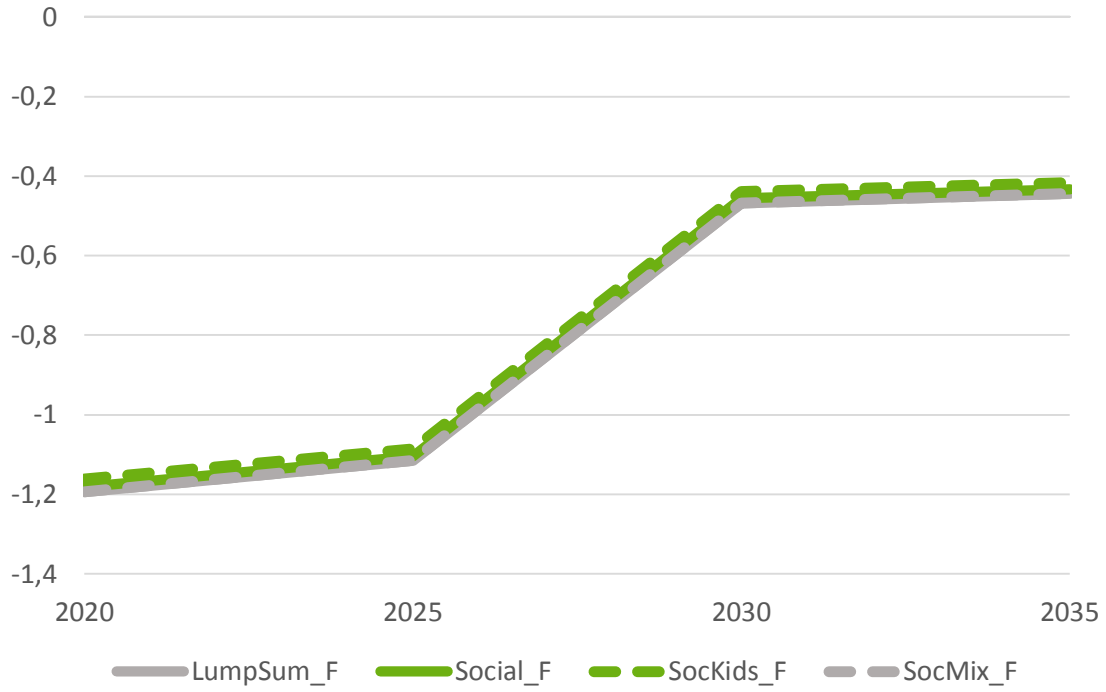


Figure 24: Consumption relative to the reference case (in %)

3.4.3.3 Distributional impacts

Total redistributed revenues are much lower in the international crisis scenarios than in the domestic policy scenarios. This is due to the revenue being raised differently (through the income tax) and with much lower additional revenue (1 bio. CHF per year). While the distributed amounts are smaller, the redistribution patterns across households in the international scenarios resemble their domestic counterparts (see Figure 25 for 2025 and Figure 26 for 2035). The results indicate that much less than 1 bio. of recycled revenues would be needed to offset regressiveness effects of the fuel price increase.

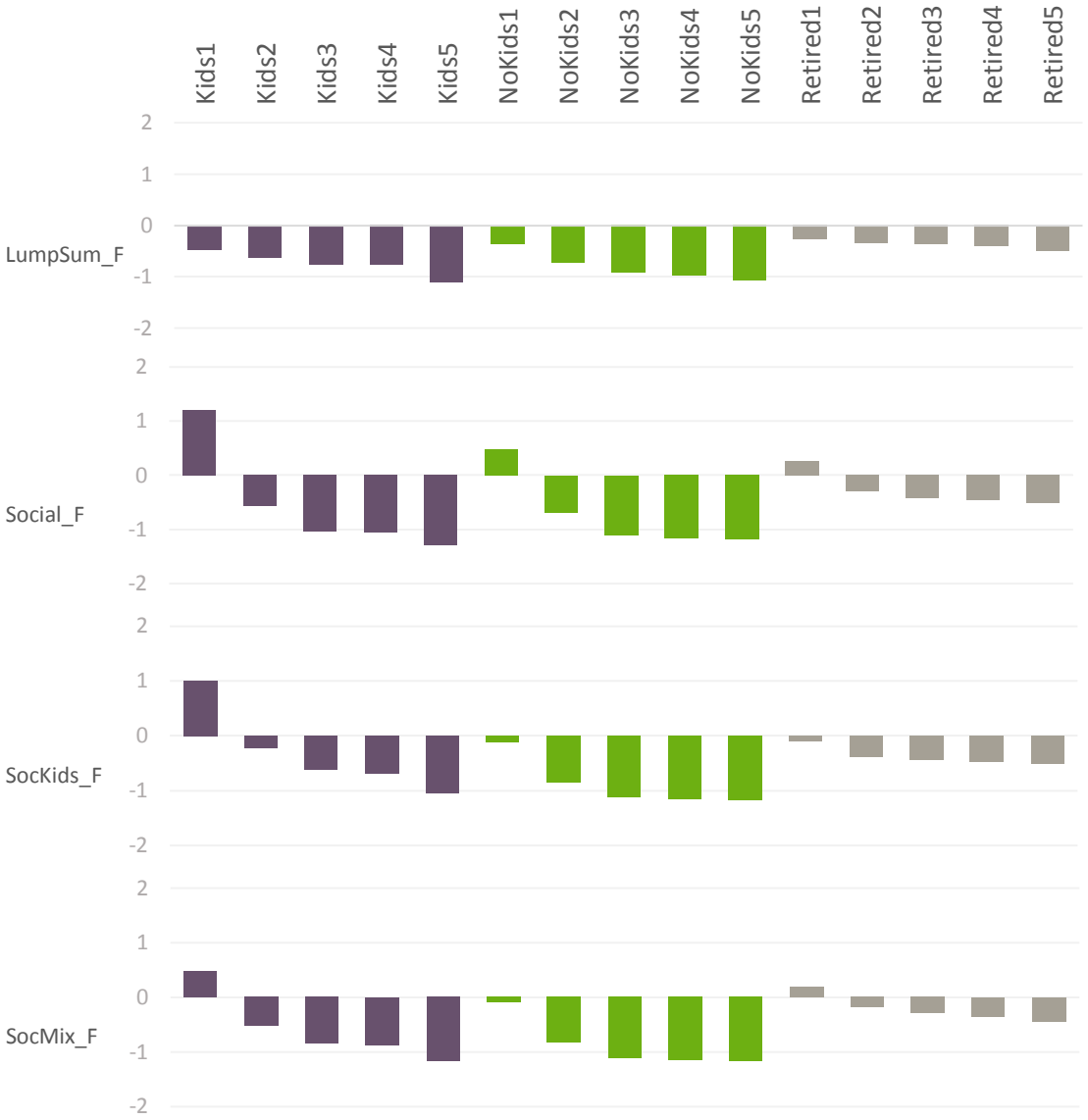


Figure 25: Welfare changes relative to the reference scenario in 2025 (in %)

As the macroeconomic cost is much lower in 2035 than in 2025, impacts are generally more favorable in 2035. By then, the scenarios predominantly become simulations of redistributive programs, which consist of raising additional income tax revenues of 1 bio. CHF in order to distribute the revenue lump-sum according to different social criteria.

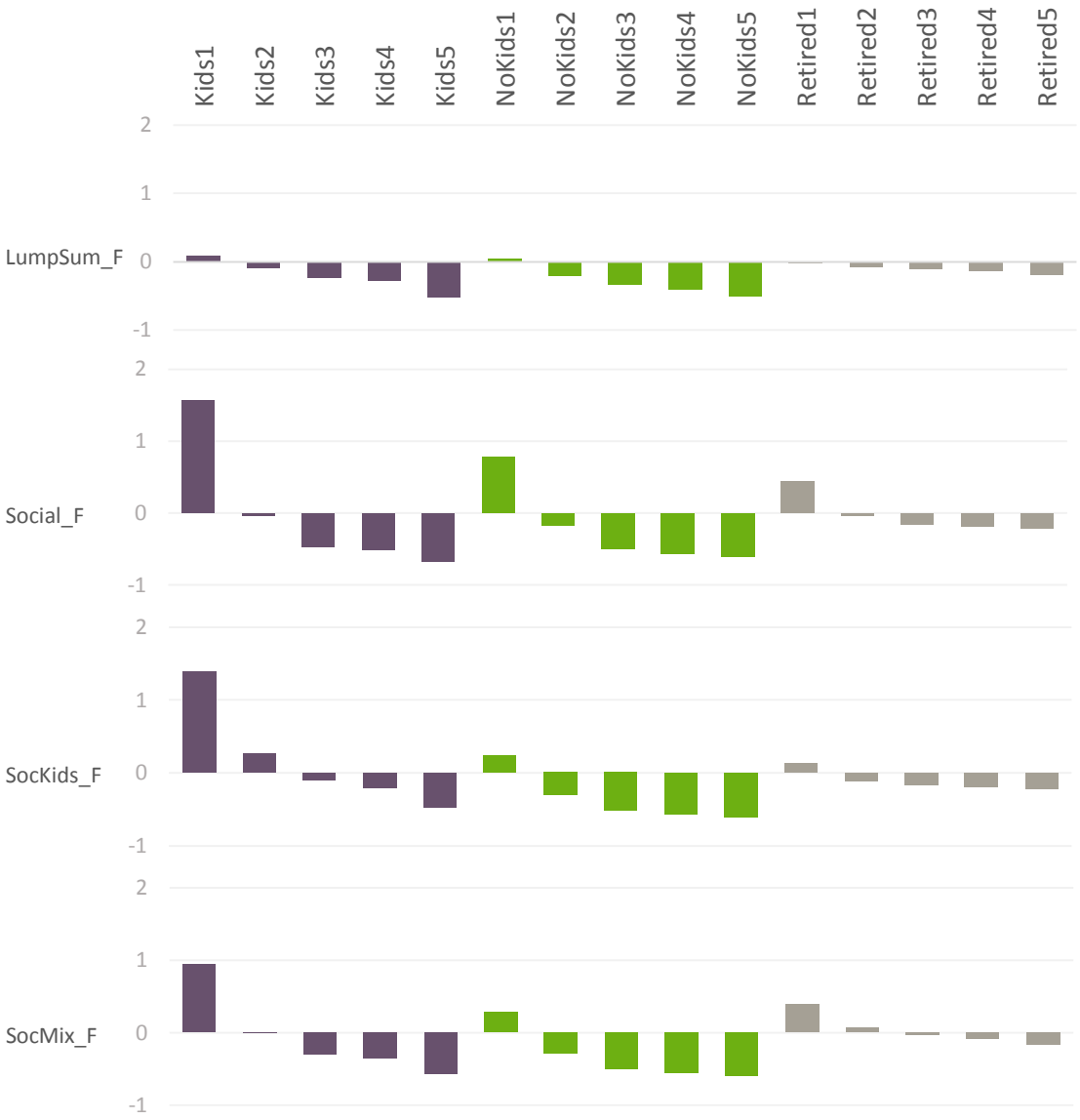


Figure 26: Welfare changes relative to the reference scenario in 2035 (in %)

3.4.4 Regional distribution of impacts

One possible concern about carbon levies is that they could affect urban and rural households to different extents. Rural households are more likely to own a car and to drive larger distances with it. Living space per person tends to be larger in rural than in urban areas. Furthermore, densification is known to reduce energy demand for heating per residential unit. The hypothesis is thus that carbon levies affect rural more than urban households.

To investigate this issue, we implement an alternative household aggregation. It distinguishes between households residing in cities, in agglomerations, and in rural areas. Each of these categories is sub-divided into five classes according to economic standard of living (see sub-chapter 3.2.2).

In the simulations, we have not found any evidence for relative disadvantages for rural households due to carbon levies. Indeed, the energy shares in total expenditure are very similar for rural and urban households. As can be expected, rural households spend roughly 50% more on transport fuels than city households (average expenditure shares are 2.3% vs. 1.5%). On the other hand, they save

more than this difference through a lower expenditure for heating fuels compared to inner city households (the respective shares are 2.1% vs. 3.1%). Differences in heating technologies are an important explanation for this: recently built single-family homes, which are rare in inner cities, are often equipped with heat pumps, sometimes with solarthermal installations or photovoltaics. Furthermore, the use of fire-wood in stove heatings is much more frequent in rural than in urban areas. Then again, district heating is more common in cities and agglomerations. However, the associated expenditure counts towards the shares provided above.

The unimportant influence of the location on carbon levy impacts contrast with the importance of social patterns, which has already been described in sub-chapter 3.4.1. There is an indirect influence of social aspects on carbon levy impacts at different locations: Rural households have a likelihood of 25% to belong to the household category with the lowest standard of living. This likelihood is significantly higher than in agglomerations (17.5%) or inner cities (19.4%). Thus, regressiveness of carbon taxes is a somewhat bigger issue for rural than for urban areas. On the other hand, our results show that using a small portion of the tax revenue for social cushioning will suffice to offset the regressiveness of the carbon levy.

Given the above analysis, it is unnecessary from an economic point of view to especially address rural issues with carbon levies. Having said this, in the political arena perceived impacts dominate simulated impacts.

4 Public Acceptability

4.1 Analysis of the environmental effectiveness of carbon taxes

- See Annex 1: Baranzini, A. and S. Carattini, 2014. Taxation of Emissions of Greenhouse Gases. Freedman B. (Ed.), *Global Environmental Change*, Handbook of Global Environmental Pollution, Vol.1, 543-560, Springer.

In a preliminary stage of the project, in parallel to the literature survey, we examined the empirical evidence on the environmental effectiveness of existing carbon taxes. We found that a number of studies point out that carbon taxes are effective as the theory predicts, provided that the policy is not designed in a way that allows for generous exemptions and exceptions. In addition, carbon taxes provide important local benefits, mainly driven by better air quality, which can represent a considerable share of abatement costs.

Furthermore, we discuss how through time carbon taxes stimulate research and development, innovation and adoption of new technologies emitting less carbon. The empirical evidence based on the Porter Hypothesis suggests indeed a positive relationship between higher energy prices and the development of green innovation. This feature of carbon taxes and carbon pricing is generally underappreciated in many discussions about technological change and climate change, where pricing is downplayed as if innovation and diffusion subsidies were sufficient (see Baranzini et al. 2016, see Annex 2). We stress that carbon pricing and technology policy are largely complementary mechanisms and should thus both be part of a climate policy package.

Finally, we cover the issue concerning the possibility of a potential Green Paradox. While the empirical assessments of the Green Paradox are currently very rare, the theoretical analysis suggests that policymakers should carefully consider the potential reactions of fossil fuel suppliers to the announced future carbon tax paths. Yet, this by no means implies that carbon taxes should not be implemented to avoid counterproductive effects. On the contrary, carbon taxes should be implemented taking into account the lessons from the Green Paradox literature, namely the risk that by anticipating extraction in reaction to a future policy tightening, fossil fuel producers can decrease the effectiveness of carbon taxes (weak version of the Green Paradox) or even lead to larger environmental damages because of the cumulative effect of greenhouse gas emissions (strong version of the Green Paradox).

4.2 Qualitative and quantitative analyses for the Canton of Geneva

This part of the project aims at better understanding and explaining the observed delay in the implementation of carbon taxes and at highlighting the implications for policymaking in Switzerland. From an economic perspective, three reasons may explain this lag:

1. First, countries may be free riding on the effort, if any, of other countries. This behavior would be fully rational in a (global) public good situation, as standard economic theory predicts. However, increasing evidence suggests that this explanation cannot be seen as complete, due to the role of social norms in social dilemmas as those resulting from the management of global commons (Carattini 2015; Carattini et al. 2015; Jordan et al. 2015; Ostrom 2009).

2. Second, carbon taxes may be ineffective. Yet, we mentioned above a set of empirical evidence proving the effectiveness of carbon taxes, assuming proper design.
3. Third, political economy reasons may provide an explanation for the lack of diffusion of carbon taxes.

The latter explanation is explored in this project. The theoretical literature already identified lobbying from e.g. energy-intensive industries as a barrier to carbon taxes. For instance, Kirchgassner and Schneider (2003) emphasize the different political economy aspects related with the implementation of environmental taxes and identify the possible winners and losers among industries, politicians and bureaucrats. In practice, the power of lobbying has proven very powerful in avoiding possible energy taxes (cf. Rocchi et al. 2014) or in softening those that were eventually implemented (cf. e.g. Bruvoll and Larsen 2004; Godal and Holtsmark 2001; Lin and Li 2011; Spash and Lo 2012).

However, lobbying from energy-intensive industries is probably not the only explanation for the lagging implementation of carbon taxes. Environmental taxes may also be unpopular among voters. The pressure of people disliking environmental taxes may be so strong to push politicians to abandon their proposed reforms (see e.g. the French case in Deroubaix and Lévèque 2006) or to reject the proposed reforms in a ballot (see e.g. the Swiss case in Thalmann 2004).

Hence, this project aims at identifying drivers and barriers to the acceptability of carbon taxes. We analyze this question by collecting original data through three surveys in Geneva and in Switzerland. We discuss in 4.2.1 the qualitative analysis administered before the quantitative surveys that will be presented in 4.2.2 for the Geneva survey and 4.3 for the Swiss survey.

4.2.1 Qualitative analysis

- Annex 3: Baranzini, A., Caliskan, M. and S. Carattini, 2014. Economic prescriptions and public responses to climate policy, Haute école de gestion de Genève. Cahier de recherche No HES-SO/HEG-GE/C--14/3/1--CH. *Submitted for publication*.

To define the main issues and then the questions of the quantitative surveys, we first administer through semi-structured interviews a qualitative survey to a small and unrepresentative sample of about 40 adults living in the Canton of Geneva. The main findings are the following:

1. First, private actions (e.g. improvements in energy efficiency) are preferred to public interventions to curb energy consumption and emissions.
2. Second, when interviewers introduce explicitly the role of the public sector, the general opinion is to limit its intervention to communication and education (i.e. suasion). Market instruments are mentioned only by few respondents, and subsidies (e.g. for public transportation) are by large preferred to taxes.
3. Third, interviewers face some resistance when they propose the implementation of a generalized carbon tax. The main reasons are related to distrust in the government and a presumed ineffectiveness of carbon taxes in changing behavior. It follows that when they ask how tax revenues should be used, most respondents suggest keeping them in the environmental domain.
4. Fourth, social cushioning for low-income households is regarded as important, but the way of financing it should not be related to environmental tax revenues.

4.2.2 Quantitative analysis

- Annex 4: Baranzini, A. and S. Carattini, 2016. Effectiveness, earmarking and labeling: testing the acceptability of carbon taxes with survey data. *Environmental Economics and Policy Studies*, DOI 10.1007/s10018-016-0144-7

We continued the investigation of carbon taxes acceptability with a survey administrated to more than 300 individuals approached in the streets of Geneva. Applying the insights from experimental economics, some respondents are requested at random to judge a potential "carbon tax", while others a potential "climate contribution". The literature already suggests several explanations for the reluctance of people to support energy and carbon taxes, also when they may be net winners. In general, people have a preference for progressive (or at least neutral) taxes, as shown by e.g. Brannlund and Persson (2012), Bristow et al. (2010) and Kallbekken and Sælen (2011). They may also be concerned about competitiveness and employment effects (cf. Thalmann 2004). Another obstacle emphasized by the literature and barely addressed by policymakers is that people often do not conceive the difference between Pigouvian and Ramsey taxes (Kallbekken et al. 2011). Hence, people may fail to understand the incentive effect of environmental taxes and thus neglect any environmental benefit from the new taxes unless revenues are explicitly earmarked (cf. the "issue-linkage" concept in Sælen and Kallbekken 2011). It follows that a frequent result in the literature is a high correlation between the perceived effectiveness of the environmental tax and its acceptability (cf. e.g. Bristow et al. 2010; Brouwer et al. 2008; Kallbekken and Sælen 2011; Sælen and Kallbekken 2011). In this context, renaming the tax differently ("climate contribution" vs. "carbon tax") can spur its acceptability (cf. Brannlund and Persson 2012; Kallbekken et al. 2011).

Our analysis contributes to existing literature not only by confirming some of its stylized facts and by broadening their scope, but also by rejecting some other conventional wisdom. On the one hand, we confirm the high correlation between perceived effectiveness and acceptability. We also find that this correlation holds for the perception of co-benefits from carbon taxes, whose existence is often neglected by the people in the sample. Given the relative magnitude of co-benefits with respect to the abatement costs, this new result has important policy implications in terms of how climate policy could or should be marketed (see also OECD 2014).

Our analysis confirms the role of earmarking revenues as a driver of higher acceptability, above all when revenues are earmarked for environmental purposes. It also describes how the need for earmarking revenues is related with the lack of trust in the government. Indeed, we show quantitatively that the correlation between perceived effectiveness and acceptability persists even if revenues are earmarked. That is, contrary to what is generally assumed (cf. e.g. Kallbekken et al. 2011), we find that perceived effectiveness increases acceptability even when revenues are earmarked for environmental purposes.

We find that perceived effectiveness may matter for acceptability much more than the potential adverse distributional and competitiveness effects. In particular, we show that competitiveness effects may not necessarily be a concern for potential voters and that distributional concerns, although they represent an issue that people care about, may not be an obstacle for acceptability. This new evidence may have important policy implications:

1. First, since we do not find a trade-off between effectiveness and competitiveness concerns, acceptability could be increased by targeting environmental effectiveness and renouncing to the exemptions to energy-intensive industries often granted for competitiveness reasons.

2. Second, we highlight that regressive carbon taxes may not necessarily be unpopular. The society's demand for equity could be met with other instruments.
3. Thirdly, we provide evidence for an effect of the labeling treatment when revenues are earmarked. With the sample in this study, the maximal acceptability would be obtained with a climate contribution with revenues earmarked for environmental purposes. With respect to labeling, we thus extend to the field the laboratory evidence found in Kallbekken et al. (2011).

The empirical approach described in this section suffers from three main limitations. All the limitations are however addressed in the study at the national scale (see next section).

The first concern is related with the external validity of the survey. Most of the insights presented here rely on the internal validity of the survey, with several questions being asked to the same participants and with the label treatment being randomly allocated. Extrapolating the results obtained with this sample to a larger population would require them to be externally valid. Indeed, the sample is drawn from the Geneva population, which, even though does not differ dramatically from the rest of the country in terms of voting behavior on such issues, may possess different concerns from the average Swiss citizen. Furthermore, even assuming that the empirical results from this analysis can be extrapolated to the whole country, Switzerland may still represent a special case with respect to other developed countries, including its European neighbors, in particular concerning possible distributional and competitiveness effects.

The second concern is on the reliability of stated preferences. The most serious obstacle limiting the transposability of stated preferences to real-life decisions is the hypothetical bias, which implies that individuals may want to appear more pro-social and pro-environmental when they answer to survey questions than what they are in reality, since the decisions they take in surveys are not binding. Furthermore, real-life decisions such as voting may be also influenced by the media and lobbying. Future research can tackle these concerns by for instance analyzing voting behavior whenever the opportunity arises. While the vote that each individual casts cannot be observed, representative surveys can recover the ballot decisions and allow for comparison with the official data. Such surveys not only allow understanding the behavior and rationales of voters, but also those of the citizens that are entitled to vote, but choose not to (see e.g. Thalmann 2004).

The third concern is related with the timing of the survey. Pressure from lobbies and media coverage increases when approaching a ballot or an electoral vote. Lobbying from energy-intensive sectors can in particular be very strong when it comes to vote on energy and carbon taxes (see Spash and Lo 2012). Both lobbying and media coverage are shown to have an effect on people's opinions on climate change and climate policy, along with other important events (Gallier et al. 2014; Jacobsen 2011; Sampei and Aoyagi-Usui 2009). To anticipate what people would vote in a particular ballot, it would thus be ideal to administer the survey in a non-neutral period (Arrow et al. 1993). However, no non-neutral period was available at the time of the Geneva survey. But it was at the time of the national survey.

4.3 National survey

4.3.1 Economic context

On March 8th 2015 the Swiss population was asked to vote on a popular initiative from the Green Liberal party aiming at replacing the current value-added tax (VAT) with an energy tax.[9] The Swiss government did not support the initiative and most other parties declared to be against it. In spite of the low probability of success of the initiative, the business organizations invested important efforts in a campaign emphasizing the limits of such proposal.

The main arguments in favor of the initiative, as raised by the Green Liberals, were the following:

1. Taxing dirty energy sources: allowing for a transition towards a more sustainable economy, by making renewable energy sources more competitive than dirty energies, without the need for additional subsidies.
2. Ensuring fiscal neutrality: replacing a tax with another that ensures the same revenues for the government, and the same tax burden for citizens and firms.
3. Helping consumers: consumers can save money on the VAT, while ecologically-friendly behavior is rewarded.
4. Reinforcing the local economy: using more renewables implies an increased independence from oil producer states and gives incentives for green innovation in Switzerland.
5. Saving on transaction costs: without the VAT, the reform would allow saving important administrative costs to firms.

The Swiss government shared most of these objectives. In February 2015 Switzerland was indeed the first country to submit a pledge to the UNFCCC pledge-and-review system in view of the COP21 in Paris. It pledged in favor of a reduction of greenhouse gas emissions of 50% by 2030 with respect to 1990 emissions. However, it criticized the decision to completely erase the VAT and replace it with an environmental tax, which is supposed to decrease energy consumption over time, and so reduce its own tax base. It also mentioned a series of concerns related with the competitiveness and distributional effects of the proposed reform. It did not propose a counter-proposal to be submitted to voters, but announced a gradual path towards higher energy prices with a climate tax starting from 2021.

The Swiss government challenged the capacity to finance in the future the important services currently funded by the VAT revenues – the main source of funding for the federal government – and mentioned in the debate a price of 5 francs per liter of gasoline to compensate for the fall in VAT revenues. This would have implied an increase in the price of gasoline of about 200%. This argument was rapidly appropriated by the political parties and organizations opposing the initiative, whose main arguments were the following:

1. Unaffordable energy prices: exploding energy prices, e.g. 5 francs per liter of gasoline.

[9] Another text was submitted to the population on the same day. It was a popular initiative of the Christian Democratic People's Party of Switzerland aiming at increasing fiscal exemptions for families with children. The initiative was rejected at 75.4%.

2. Jeopardizing the funding of crucial government's tasks: while the VAT represents a stable source of revenues, the energy tax rate would have had to be regularly increased (and so the price of energy) to keep revenues stable.
3. Adverse competitiveness effects: the country's prosperity at risk due to a loss in competitiveness.

We consider that the last argument resonated particularly strongly in the specific period of the vote, which followed of only a few weeks the decision of the Swiss National Bank to drop its euro peg. The following appreciation of the Swiss franc was believed to be going to put under extreme pressure the many export-oriented sectors of the Swiss economy.

The popular initiative was rejected at 92%. A few weeks after, the government announced its strategy to meet the above-mentioned CO_2 emissions abatement pledge, as well as to facilitate the planned phase out of nuclear energy. This strategy consists in higher taxes on electricity and heating fuels, while the precise tax rates are left to further discussion and dependent on the final objectives in terms of greenhouse gas emissions abatement. Gasoline is also expected to be taxed, but only after a period of adaptation.

We exploit the specific context of this ballot and the debates following the presentation of the Swiss government's energy strategy to administer the national survey in a non-neutral period. As part of a companion project, we also analyze the data from the VOX survey on this ballot.

4.3.2 Survey setting

It is particularly hard to observe real behavior (revealed preferences) as expressed in ballots. Even in Switzerland, ballots on energy taxes are relatively rare and voters express their opinion on a specific proposal. Previous research has shown the importance of the policy design (Bristow et al. 2010; Kallbekken and Aasen 2010; Sælen and Kallbekken 2011), and it is thus crucial to have information on different policy attributes and the combination thereof. The only way to obtain such information from a relatively large sample – that is, larger than what is usually available in the laboratory – is to rely on stated preferences.

It is however possible to set a survey using a choice experiment design, making choices and trade-offs the most realistic possible and thus reducing the hypothetical bias. In our choice experiment, we present all respondents with three potential choices: a carbon tax with a first design, a carbon tax with a second design, and the status-quo. The design of carbon taxes is dependent upon the combination of two attributes: the tax rate, measured in terms of Swiss francs per ton of CO_2 emitted, and the use of tax revenues (see Table 8). Each respondent has to select one of the three options in 8 different hypothetical ballots, with the attributes being randomly combined at each ballot. Respondents are given one of the 15 randomly-generated versions of the questionnaire, depending on the language spoken.

Table 8: Attributes

Tax Rate (CHF/tCO₂)	60	90	120	150
Use of revenues	Income tax rebates	VAT rebates	Lump-sum transfers	Social redistribution	Strengthening of the environmental impact (offsets)

As all combinations included in the choice experiment previously entered the model simulations (see chapter 3), we are able to provide information to the respondents on the order of magnitude of the following impacts of each combination of tax rate and use of revenues:

- Expected increase in the price of gasoline, diesel and heating fuel (in cents per liter, range of about 5 cents);
- Expected reduction in greenhouse gas emissions (in percentage). Regardless of the use of revenue, a higher energy price in Switzerland is associated with lower emissions. When revenues are used to strengthen the environmental impact of the policy, foreign offsets are purchased and we thus estimate the effect on greenhouse gas emissions abroad as well, relative to the emissions of Switzerland;
- Expected impact on the overall purchasing power of Switzerland, based on a proxy for overall consumption (in percentage);
- Expected impact on the overall purchasing power of low-income households (five categories from – to ++, scales in percentage provided to respondents in a separate note).

We thus provide respondents with sufficient information for the most relevant variables that in the literature are shown to guide behavior, mimicking the effort that the government would (or at least should) do to inform the population in view of a ballot. The literature and our previous analyses also suggest that respondents may underestimate the effectiveness of carbon taxes while possibly overestimating the competitiveness and distributional effects, in particular in presence of lobbying from energy-intensive industries. In this setting, respondents are instead carefully explained the functioning and effects of carbon taxes. We expect this specific setting to lead to different results with respect to what most often found in the literature and possibly in our Geneva survey. We also give to respondents the possibility to reject all proposals, allowing us to measure not only the relative preferences for a given attribute, but also the overall likelihood that a carbon tax can ever become acceptable.

We hired the agency Demoscope to administer the survey, which was structured as follows. First, a set of about 4'000 potential respondents were randomly selected and received by post mail the following material:

- a letter presenting the study and encouraging potential respondents to become familiar with the issue and participate in the survey if called by phone,
- a detailed one-page fact sheet explaining how carbon taxes work and the main implications of each recycling option,
- the full set of choice cards for all 8 votes displaying the attributes and related impacts of each choice.

Second, a sub-set of the about 4'000 potential respondents is contacted and driven through the questionnaire, provided that she agrees to participate in the survey. When it comes to taking a decision on the ballots, all respondents are read a short and unique text describing the effects of each combination. This ensures that all respondents are provided with the same information, even those that did not spend time reading the material that they received at home. As many already "voted" at home as for postal vote, respondents were given the possibility to skip the oral explanations and directly express their opinion selecting the most preferred choice between the two carbon taxes and the "none" option.

As requested, the survey stopped when the quota of 1'200 nationally-representative respondents was reached.

4.3.3 Descriptive statistics

The main descriptive statistics are provided in Table 9.

Table 9: Nationally representative survey: summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Socio-economic characteristics					
Gender (male)	0.486667	0.500031	0	1	1,200
Age	51.71083	15.26269	18	94	1,200
Nationality	0.896667	0.304521	0	1	1,200
Household size	2.884167	1.332502	1	8	1,200
Years of education	13.99164	2.938123	9	18	1,196
Main transport mode					
Private vehicle	0.480687	0.499841	0	1	1,165
Bicycle	0.162232	0.368822	0	1	1,165
Bus	0.188841	0.391551	0	1	1,165
Environmental concern and social preferences					
Global warming is very threatening	0.400833	0.490272	0	1	1,200
Global warming is somewhat threatening	0.471667	0.499405	0	1	1,200
Environment vs. growth	0.734167	0.44196	0	1	1,200
Gradual carbon tax	0.635	0.481631	0	1	1,200
Generalized trust	0.549036	0.497798	0	1	1,193
Confidence in the government	0.810009	0.392461	0	1	1,179
Political preferences					
Participation in last 4 ballots	3.195305	1.235204	0	4	1,065
Party at last elections					
UDC-SVP (& Lega)	0.232484	0.422753	0	1	628
PS-SP	0.28344	0.451027	0	1	628
PLR-FDP	0.175159	0.380406	0	1	628
Center (PDC-PBD-PEV)	0.18949	0.39221	0	1	628
Greens (& Green Lib.)	0.119427	0.324549	0	1	628
Income					
<CHF 35’000	0.059561	0.236796	0	1	957
CHF 35'000-50’000	0.144201	0.351477	0	1	957
CHF 50'000-80’000	0.242424	0.428774	0	1	957
CHF 80'000-120’000	0.304075	0.460255	0	1	957
CHF 120'000-160’000	0.153605	0.360758	0	1	957
CHF 160'000-200’000	0.047022	0.211797	0	1	957
>CHF 200’000	0.049112	0.216214	0	1	957

4.3.4 Preferences for attributes and carbon taxes

In this section, we assess the influence of each attribute on the individual decision to accept or not a carbon tax as proposed in the 8 ballots of our choice experiment.

Based on the previous discussion, we formulate a set of hypotheses for the attributes in our study:

> **[Hypothesis 1] Tax rate:** We expect higher tax rates to lead to lower acceptability for carbon taxes, everything else equal.
>
> **[Hypothesis 2] Revenue recycling:** We expect acceptability to vary substantially depending on the use of fiscal revenues. We expect use of revenues for environmental purposes to increase acceptability the most, followed by social cushioning addressing potential distributional effects. We expect lower acceptability with revenue-neutral recycling, as this approach (taxing here and reducing taxes elsewhere) is usually a criterion that the taxpayers do not request, nor probably understand. We do not have specific priors on the relative ranking within revenue-neutral recycling methods, i.e. income tax rebates, VAT reduction and lump-sum transfers.

Table 10 presents our first estimates. We display marginal effects from conditional logit for straightforward interpretation. Column (1) shows estimates for the full sample, i.e. 1189 individuals[10].

As expected, a higher tax rate is linked to a lower acceptability, everything else equal. However, the difference between 0 and 60 francs per ton of CO_2 is relatively small in comparison with the other tax rates. Hence, in some situations, people might have preferred to select a carbon tax, with a moderate tax rate, than no carbon tax at all. Given that at the time of the survey the tax rate was already fixed at 60 francs per ton of CO_2, we did not include in the survey e.g. a 30 CHF tax rate.

Based on the evidence from Table 10 we validate hypothesis 1. Furthermore, we note that except from 0 to 60 francs, the decrease of the acceptability coefficient is almost linear, suggesting that a well-shaped linear demand would be a good approximation for carbon taxes. This linearity allows speculating on the negative impact on acceptability of an extremely high rate, as the one suggested by the popular initiative promoted by the Green Liberals and rejected by the Swiss population. While promoters of and opponents to the popular initiative were disagreeing on the proposal's expected impact on energy prices, depending on the time horizon that they used in their campaigning, our most conservative computations suggest that in the short term the tax rate would have had to be of at least 300 CHF per ton of CO_2. Figure 27 extrapolates linearly from the probabilities of success that we observe based on the tax rates proposed by the survey and predict the outcome of an initiative proposing a tax rate of 300 CHF per ton of CO_2. For a like-to-like comparison, Figure 27 shows only the predicted likelihood of success if revenues were to be used as proposed by the Green Liberals. While interpreting any out-of-sample prediction always requires a lot of precaution, our extrapolation provides support for the external validity of our choice experiment. At a rate of 300 CHF per ton of CO_2 the predicted support is virtually zero, which is very close to the frequency of yes-vote

[10] 11 respondents did not answer to the vote questions. We treat them as missing values. To increase the reliability of our data, interviewers received explicit instructions preventing them from insisting to have an answer when respondents were unable to provide one. Most of these missing observations are related with people aged 60 and more.

received in the public ballot. That is, if anything, our choice experiment predicts less support than the ballot.

Table 10: Nationally representative survey: Estimates from conditional logit

	(1)	(2)	(3)	(4)
Tax rate				
0 CHF (reference)				
60 CHF	-0.0179	-0.0298	-0.0223	-0.0432*
	(0.0154)	(0.0161)	(0.0159)	(0.0201)
90 CHF	-0.0515***	-0.0592***	-0.0558***	-0.0697***
	(0.0153)	(0.0160)	(0.0158)	(0.0205)
120 CHF	-0.107***	-0.122***	-0.108***	-0.122***
	(0.0154)	(0.0160)	(0.0159)	(0.0202)
150 CHF	-0.177***	-0.186***	-0.183***	-0.200***
	(0.0157)	(0.0163)	(0.0162)	(0.0207)
Revenue recycling				
Income tax rebate (reference)				
VAT reduction	-0.0132	-0.0104	-0.0152	-0.0162
	(0.0113)	(0.0119)	(0.0117)	(0.0155)
Lump-sum redistribution	0.137***	0.136***	0.136***	0.127***
	(0.0117)	(0.0123)	(0.0122)	(0.0156)
Social cushioning	0.144***	0.145***	0.145***	0.135***
	(0.0117)	(0.0123)	(0.0121)	(0.0156)
Environmental recycling	-0.0209	-0.0289*	-0.0244	-0.0555**
	(0.0131)	(0.0140)	(0.0136)	(0.0179)
Number of individuals	1189	1066	1114	650
Number of votes	28536	25584	26736	15600
Pseudo-R^2	0.0342	0.0360	0.0351	0.0404

However, a better outcome could probably have been possible with a different use of tax revenues. As the estimates show, reducing the current value added tax is not linked to any higher acceptability with respect to income tax rebates (the reference case, omitted due to multicollinearity). This result comes as expected and confirms our hypothesis on the low support for revenue neutrality. In this respect, it is important to recall that based on the modeling exercise, we do not find a double dividend with these two ways to recycle revenues, the net effect on the domestic purchasing power being broadly as negative as with the other types of recycling. Hence, respondents informed about the potential beneficial effects of reducing distortionary taxes knew that they should not be expecting a double dividend from lower income taxes, or a reduction in the value-added tax.

We are however surprised by the estimates concerning lump-sum transfers, environmental recycling and to some extent social cushioning. The results that we provide for these variables are novel in the literature and deserve to be analyzed carefully. In particular, we find that lump-sum transfers and social cushioning are the most preferred options for recycling, while environmental recycling through the purchase of foreign offsets does not seem to obtain the support that it usually does. We have an explanation for all the three facts, all of them coming with very important policy implications.

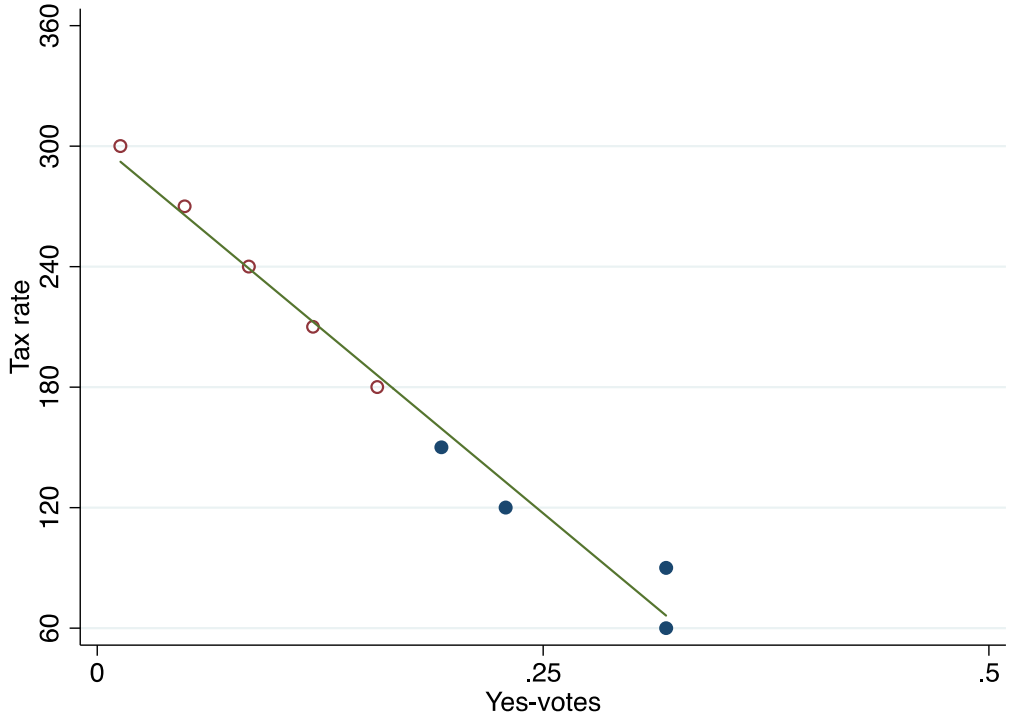


Figure 27: Prediction with VAT recycling as in the Green Liberals' initiative

We point to two complementary explanations for the relatively high acceptability of the lump-sum redistribution. First, the modeling exercise suggests moderate net gains for low-income households with lump-sum transfers. Only social cushioning does better, while the remaining types of recycling involve regressive effects. Respondents are informed about this fact and internalize the beneficial distributional properties of lump-sum redistribution. Second, respondents are informed that the current carbon tax on heating fuels is mostly redistributed through lump-sum transfers. This information could have increased the legitimacy of this type of recycling. We highlight that our survey in Geneva shows that only a limited number of individuals were aware of the current heating fuel tax existing in Switzerland, and a smaller proportion is expected to have knowledge on the way revenues are redistributed (cf. Baranzini and Carattini 2016). Hence, our results support the choice of the Swiss Government to privilege full lump-sum redistribution in its Energy Strategy 2050. However, we stress that it will be crucial to inform the population on the reasons for this choice and in particular on the progressive effects of lump-sum transfers, possibly based also on empirical assessments on the many years of carbon tax on heating fuels and not only on analyses from modeling exercises.

The most important result in Table 10 concerns the low demand for recycling fiscal revenues for environmental purposes. This result is at odds with most of the literature on the acceptability of environmental taxes (see Drews and van den Bergh 2015 for a review). In our opinion, the explanation for this novel finding is twofold.

First, we provide respondents with an estimate of the emission abatements due to carbon taxes. Interviewers were instructed on how to provide simple explanations on the price sensitivity of consumers and they reportedly had to use such information to answer the general public's curiosity on the bases for the scenarios included in the choice cards. Hence, our survey addressed by construction one of the main obstacles to carbon taxes: perceived environmental ineffectiveness, which is the reason why people often ask fiscal revenues to be earmarked for environmental purposes. Since all carbon taxes in the survey are shown to be effective, and to the extent that the scientific credibility

of our study and institutions was not challenged, the main driver for the demand for environmental recycling is wiped out.

Second, the demand for environmental recycling may not necessarily correspond to the most effective way of obtaining additional emission abatements as economists would interpret it. Even with our conservative estimate for the price of emissions on foreign carbon markets, we can have tremendous emission abatements with the revenue of a carbon tax between 60 and 150 francs per ton of CO_2. All scenarios imply substantial negative emissions: even the lowest tax rate leads to abatement equivalent to five times total Swiss emissions. At the current carbon price levels, it would be very tempting for policymakers to purchase many years of carbon neutrality and so achieve at an extremely low cost long-term pledges, such as "the balance" between emissions and removals by sinks. However, we understand that the respondents in our survey may wonder why compensating so much. The general public may also do not like the purchase of carbon credits in foreign countries and would prefer emissions to be abated at home. Indeed, people may have a preference for local investments, which provide a number of local co-benefits, and may also have ethical or practical reservations with respect to the use of offsets in general. There are many practical reservations in the case of carbon offsets, even though only a few of them concern withdrawing of emissions allowances from the carbon market as contemplated in our scenarios (see Conte and Kotchen 2010). Ethical reservations apply instead to all types of offsets. The main critiques challenge the commoditization of nature and the legitimization of carbon-intensive lifestyles that offsetting practices seem to provide (Anderson 2012).

Finally, we note that the relative effect of social cushioning does not completely surprise, given the low demand for environmental recycling through offsets. We also stress that distributional effects were made completely salient to respondents. Social cushioning was shown to provide the most progressive effects over all types of recycling, although lump-sum transfers perform similarly with moderate tax rates.

Figure 28 extends the simulation of Figure 27 with the most popular recycling options, lump-sum recycling and social cushioning. As Figure 27 already showed, our choice experiment suggests that even with an extremely low tax rate recycling through VAT rebates could hardly provide a majority in favor of a carbon tax. With social cushioning, and especially lump-sum transfers, the picture is different. While none of the two recycling options lead us to a majority with the tax rates considered by our survey, the prediction for recycling through lump-sum transfers suggests that anything below 60 would be in principle acceptable. While we recall the necessary precautions in taking at face values such predictions, we stress how recycling modes can completely shift the demand for carbon taxes, possibly also beyond the required threshold to make them acceptable. Based on these findings, we reformulate hypothesis 2 as follows:

> **[Hypothesis 2] Revenue recycling** We expect acceptability to vary substantially depending on the use of revenues. In relative terms, we expect lower acceptability with revenue-neutral recycling, as revenue neutrality (taxing here and reducing taxes elsewhere) is an approach that the taxpayers probably generally do not request, nor understand. This is particularly true in the absence of an expected double dividend. Lump-sum redistribution can be associated to higher acceptability, provided that its progressive properties are made explicit. If distributional effects are salient, social cushioning and lump-sum redistribution can lead to higher acceptability. Recycling for environmental purposes may not be particularly demanded, provided that the effectiveness of carbon taxes is guaranteed *ex-ante*. This effect may in

part be driven by the proposed type of environmental earmarking, such as the purchase of foreign carbon credits.

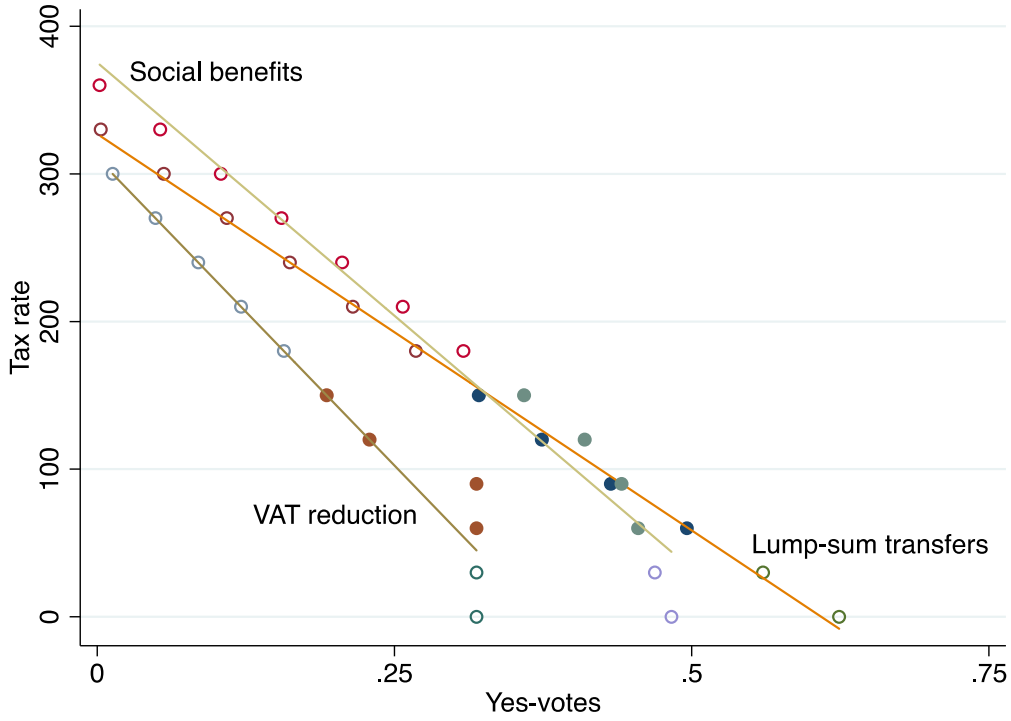


Figure 28: Prediction with recycling as in the Green Liberals' initiative, with recycling through social benefits, and with recycling through lump-sum transfers

4.4 Some lessons

In the following lines we discuss some potential lessons from this chapter. We do this based on the two dimensions that are most relevant for the design of carbon taxes, namely the tax rate and the use of revenues.

Tax rate

We find that higher tax rates clearly imply lower acceptability. This recalls once again the sensibility of the general public's preferences with respect to the cost of climate policy, above all when the latter is as salient as with carbon taxes. As pointed out in the literature, this reminds to policymakers the importance of the politics of small steps. In the specific case of Switzerland, we would suggest to first restore economic efficiency by introducing a tax rate for gasoline equal to the current tax rate for heating fuels and only in a second stage considering a tax rate increase. Yet, we are aware that resistance to the taxation of heating fuels could be lower than for all fossil fuels as in our study.

Several studies suggest that the acceptability for a given instrument increases when the instrument is in place. One reason for this is the limited effect on relative consumption: once the tax in place, people realize that their purchasing power compared to the other people is practically unchanged (Gowdy 2008; Howarth 2006). A second reason relates with the use of the generated fiscal revenues: revenue neutrality can increase acceptability *ex-post*, once people see that they are given some of the money back, provided that the redistribution is sufficiently salient. With full redistribution some households may even be net winners. Experiences with environmental taxes tackling local externalities suggest that there may also be a third reason, linked to the generalized issue of perceived ineffectiveness. As discussed, the general public tends to underestimate the effectiveness of environ-

mental taxes, especially absent any recycling for environmental purposes. However, if the effect of the policy is observable, people may review their beliefs *ex-post*, causing an important gap between perceived effectiveness (and acceptability) *ex-ante* and *ex-post*. Evidence in this sense has been provided for instance on pricing garbage by the bag in the quasi-experimental context of the Canton of Vaud's forced adoption (Carattini et al. 2016). Based on this principle, Kallbekken and Sælen (2011) remind the importance of trial periods when new instruments are introduced (see also Cherry et al. 2014). Trials contributed for instance to the political support – expressed in the ballot of – to the Stockholm congestion charge. Trials might also have contributed to higher acceptability in Gothenburg, even though the policy was eventually rejected. In all cases trials play an informative role and allow minimizing the gap between perceptions on and the actual consequences of a given policy.

Starting at a moderate price level would also reduce the opposition from energy-intensive lobbies. However, it is important that policymakers possess estimates of the potential competitiveness effects of carbon taxes. These are indeed likely to be small overall and should thus not be over-emphasized. The general public is likely to be ready to give up a bit of economic growth, if they have no doubts on the environmental effectiveness of the measures that they are supporting. Competitiveness effects on a few industries may be larger however. Policymakers should not forget that the aim of incentive taxes is to redirect consumption and production towards more sustainable goods. While carbon leakage is an issue – depending on the realization of Paris' pledges – it would be naïve not to consider that a transition toward a more sustainable economy does require the dirty activities to reinvent themselves or to go out of business.

Recycling

As expected, we find that revenue-neutral recycling through VAT is not the way to go to maximize acceptability. We are not surprised by this result, also in the light of the outcome of the March 8th ballot. However, all other findings come with original policy implications. In particular, our findings support the decision of the Swiss government to choose a full lump-sum recycling in the future extension of the current carbon tax on heating fuels to all fuels. Nevertheless, policymakers should be reminded of the important effort that we did to reduce the informational gap between the general public and economists.

We provided respondents with clear, extensive, but concise information on how carbon taxes work, on the mechanisms through which higher energy prices lead to lower energy consumption – including scenarios for emission abatements – and on the distributional effects of each type of revenue recycling for any given tax rate. While doing this, we aimed at reproducing the informative booklets that the Swiss government prepares in view of all upcoming ballots. However, scenarios and quantitative assessments are often absent in the real informative booklets provided by the Swiss government. We believe that explaining how lump-sum redistribution works and how it can be progressive will be a first step in favor of higher acceptability for the proposed generalized tax on all fuels. We recall that the awareness on the current carbon tax and its redistributive mechanism is surprisingly low as measured by the Geneva-based survey. We note that the demand for progressive effects depends on how salient distributional effects are. Lump-sum transfers seem to be an administratively simple and fair way of ensuring revenue neutrality. Marketing them as such is very likely to positively contribute to their popularity. Providing additional information in the healthcare bill through which the refund takes place may also help increasing awareness about lump-sum recycling.

Based on our results, we expect that providing figures for the estimated emission abatements will improve acceptability and decrease the demand for environmental recycling. In this case, it will be important to explain to the population how the incentive effect works. The credibility of the scientific community may play a role in this context. We also indicate the importance of stressing the existence of co-benefits for the local population. The use of specific labeling reminding the necessity to contribute to climate change mitigation may also foster political support for climate policy, as shown in the Geneva-based survey (cf. Baranzini and Carattini 2016). In this respect, the decision of the Swiss government to rename its CO_2 levy "climate levy" should increase its acceptability.

We note that any future plans of purchasing foreign carbon credits should take into account the possible political barriers. Economic efficiency supports foreign abatement, and a future integration of carbon trading markets at the worldwide scale may provide the necessary acceleration in the transition towards a low-carbon economy, as suggested by Article 6 of the Paris Agreement. In spite of the efficiency rationales, resistances may however occur and the Swiss government should start already now to build consensus in favor of integrated carbon markets and financial funds transferring resources from high- to low-income countries. The Swiss government should also play an active role in fixing the weaknesses of the current schemes, in particular the room for abuse in the Joint Implementation framework (see Schneider and Kollmuss 2015) and the potential perverse effects at the country level of the Clean Development Mechanism (see Tirole 2012).

5 Conclusions

Surveys and economic analysis yield very different results concerning the desirability of environmental tax reforms and their preferred design. The general public is skeptical about such tax reforms, especially about their environmental effectiveness. Most economists are still convinced of the efficiency and effectiveness of such reforms. These desirable properties are also confirmed by our CGE simulations.

In democracies, the policy preferences of decision-makers and voters should stand above the view of "technocrats". At the same time, informing the public and elected officials about scientific findings is a significant part of the policy-making process. Also, the administration has a crucial role in designing the details of policies and should thus be informed about which policy instruments work in practice (i.e. evidence-based policy-making).

A common argument by both the public and many economists against environmental tax reforms is that they have regressive distributional consequences: The argument goes that poor people spend a higher share of their income on energy and profit less from tax cuts. The international literature shows that this may well be the case, but that composition of income effects can reverse this effect (Oladosu/Rose 2006). In some countries or regions, even the CO_2 tax itself may be progressive (see Beck et al. 2015 for British Columbia).

In Switzerland, there is indeed a reduction of the share of energy in consumption with income. Thus, CO_2 levies in Switzerland tend to be regressive from a composition of consumption point of view. Pure tax reforms are even more regressive through the tax reductions, if they benefit higher-income households more. This is especially pronounced when marginal income tax rates are lowered proportionally, as in our scenario IncTax. Social cushioning through tax reform thus requires more than just proportional rate reductions, e.g. higher basic allowances.

It is doubtful, however, whether this direction of reform will sound convincing to citizens. In general, they tend to favor subsidies over taxes, following the idea that – rather than taxing emissions – environmentally friendly behavior should be rewarded. To the vast majority, the purpose of recycling the revenues of an environmental tax through other tax cuts seems unclear. If this is what we wanted, why would we raise another tax in the first place?

There is a point in this latter argument even from an economic point of view. The discussion on multiple dividends of environmental tax reforms mixes different objectives, which does not appeal much to citizens. Indeed, mixing objectives usually does not appeal to economists either. Following the Tinbergen rule, most economists reiterate that every objective should be addressed with its own policy instrument. While one can argue that raising one tax and lowering another one are two separate instruments, combining these two measures into one reform (e.g. replacing the value added tax through an energy tax, as proposed by the popular initiative defeated in March 2015 in Switzerland) is not as compelling as some environmental economists might suggest. One important reason for this is that, in most cases, the non-environmental dividends could be achieved in other ways. The fact that they haven't been reaped may be due to their low position on the political agenda. This lack of perceived urgency makes it unlikely that promoting the respective dividend creates major public support. It is particularly difficult to excite any non-economist with arguments about reduced excess burden of taxation when non-economists don't know what this is or why excess burden of taxation would be a relevant category at all. They might at most accept that a tax with disproportionally high

administrative costs is repealed by the environmental tax reform, but this tax must be well chosen, as the resounding failure of the popular initiative "Replacing the value added by an energy tax" has shown.

Social objectives find more sympathy. In accordance with the second fundamental theorem of welfare economics, our simulations show that (almost) any distributional goal can be attained with customized lump-sum transfers. While, in reality, the precision of targeting may be limited, there are many instruments to aim at preferred distributional outcomes, such as child benefits, old age pensions, or per capita lump-sum payments through health insurance.

Inferring from existing policies, the correction of the primary income distribution does not seem to be a major priority in Swiss politics, although for some cantons this may be different. The household data reveal that the current tax system in Switzerland is not significantly progressive overall when social security contributions and health insurance premiums are taken into account. The specifics depend on the canton. The AHV/AVS old age pensions system has important social components. Having children, however, clearly increases the likelihood of having a low equivalent income and standard of living.

Reforms, e.g. of the taxation for married couples, have repeatedly failed, partly because benefits to one group imply losses for other groups or burden public budgets. As there is no efficiency dividend for environmental tax reforms with lump-sum revenue recycling, the losers vs. winners problem remains. This problem also concerns economic sectors, with e.g. transport, gas and oil industries as predictable losers. With federalism, even revenue and expenditure shifts between public entities can be an issue.

Currently, two thirds of the revenue of the CO_2 levy on heating fuels are redistributed to households (lump-sum per capita) and firms (proportional to paid wages). This has apparent advantages:

- Acceptance could be raised, because everyone receives an equal amount and thus benefits from the recycling. Unfortunately, awareness among households for the redistribution of revenues from the CO_2 levy is very low.
- Our simulations show that per capita lump-sum recycling makes CO_2 levies clearly progressive.
- The revenue recycling is automatic, which makes it possible to claim that there is no increase in the public budget. In contrast to this, raising CO_2 levies to finance social or environmental programs may face resistance due to the expansion of government activity and administrative costs, among other things.

The disadvantage of lump-sum recycling is the efficiency loss in comparison with pure tax reforms. We can confirm, however, the result of Imhof (2012), that the foregone improvement in excess burden is rather small, especially when very regressive variants (recycling through income taxes) are not an option anyway.

The remaining third of Swiss CO_2 levy revenues is earmarked for CO_2-reducing measures (buildings program and technology fund). We find that environmental earmarking clearly obtains the highest acceptance rates of any recycling variant. To many citizens it seems obvious that, as a CO_2 levy has an environment and climate related purpose, this is also what the revenues should be used for – also because they doubt the environmental effectiveness of a CO_2 tax.

It is a major challenge to design such environmental recycling in an efficient and effective way. Efficiency highly depends on the policy instruments chosen: Would investment and technology choices be taken politically or largely by private investors? What would be the transaction costs e.g. of program implementation and monitoring?

When fossil fuel combustion is reduced, there are sizable secondary benefits, especially from health improvements due to lower air pollution (see e.g. Ecoplan 2012b), which need to be taken into account. Thus, CO_2 levies with environmental revenue recycling could be an attractive option under welfare considerations as well, provided that they are designed in such a way that they are as efficient as possible and effective in reducing fossil fuel use. How many programs fulfilling these requirements are conceivable, and what would be their maximum reasonable size? The existing CO_2 compensation schemes (e.g. Klik, EnAW, Cleantech) sometimes have difficulties to delineate between mutual projects, which could indicate size limits for domestic CO_2 compensation schemes.

Next to the current recycling through the buildings program and the technology fund, the feed-in tariffs for electricity from renewables sources could be expanded. This seems to be a favored option for many citizens: Supporting renewables is the single most given answer for recycling preferences when no preselected list of options is provided. It has to be kept in mind, however, that today many projects fail to come into existence due to long and complicated approval procedures. It remains still open how courageous we will be in practice when it comes to reshaping the energy system. Certainly, trying to spend resources for programs which are obstructed through other channels would not yield the desired outcome.

Buying international greenhouse gas emission offsets, e.g. allowances from the European emissions trading system, is yet another option. At current and currently projected prices, this is a cheap way to offset Swiss emissions. With ambitious domestic abatement objectives, it is not unrealistic to use revenues from the CO_2 levy to offset total Swiss emissions several times, although at a significant cost in terms of domestic consumption and welfare. Replacing domestic abatement by imported offsets could be a cheap option, but secondary benefits of domestic abatement as well as international commitments need to be taken into account. The internationally communicated domestic greenhouse gas abatement objective for 2030 is -30% with respect to 1990. Furthermore, it is questionable whether buying foreign emission offsets is the type of ecological earmarking which many citizens would like to see.

In summary, environmental motivation is the much stronger argument for environmental tax reform than efficiency improvements for the tax system. The latter argument is understood by few, while using revenues of environmental levies for environmental purposes appeals to many, even though it is a challenge to design additional environmental programs which are sufficiently efficient. Reserving a share of the revenues for lump-sum recycling can address social concerns. When environmental programs are financed with revenues from the CO_2 levy, this could relieve other sources of financing. Provided that these savings are passed on to citizens, tax cuts could result in the end, which – to please also the neoclassical economists – would enhance efficiency of the reform.

As environmental motivations are key to the acceptance of carbon taxes, it helps to inform the public about the positive effects of CO_2 levies: they are effective in reducing emissions, there are sizeable domestic co-benefits of abatement, and at the same time the effects on international competitiveness are smaller than usually perceived. Revenue recycling needs to be advertised much more than through the existing small note in Swiss health care bills, which remains unnoticed by many citizens. For instance, personal annual reimbursement checks have proven to be effective in raising the ex-post acceptance with existing green tax schemes. Generally, acceptance of environmental tax reform tends to be higher ex-post than ex-ante. Communicating well the advantages of the reform is especially effective in this respect.

References

Anderson, K., 2012. The inconvenient truth of carbon offsets. Nature News 484, 7.

Armington, P. S., 1969. A theory of demand for products distinguished by place of production. International Monetary Fund 16 (1), 159–178.

Arrow, K., R. Solow, P.R. Portney, E.E. Leamer, R. Radner and H. Schuman, 1993. Report of the NOAA Panel on Contingent Valuation.

Ban, K. and A. Okagawa, 2008. Estimation of substitution elasticities for CGE models, Discussion Paper 08-16, Discussion Papers. Economics And Business. Graduate School of Economics and Osaka School of International Public Policy (OSIPP), Osaka.

Baranzini, A. and S. Carattini, 2016. Effectiveness, earmarking and labeling: testing the acceptability of carbon taxes with survey data. Environ Econ Policy Stud 1–31.

Baranzini, A., J.C.J.M. van den Bergh, S. Carattini, R. Howarth and E. Padilla, 2016. Seven reasons to use carbon pricing in climate policy, Grantham Research Institute on Climate Change and the Environment Working Paper 224, London School of Economics and Political Science, London.

Barker, T. and J. Köhler 1998. Equity and ecotax reform in the EU: achieving a 10 per cent reduction in CO_2 emissions using excise duties. Fiscal Studies, 19 (4), 375-402.

Beck, M., N. Rivers, R. Wigle and H. Yonezawa, 2015. Carbon tax and revenue recycling: impacts on households in British Columbia. Resource and Energy Economics 41, 40-69.

Böhringer, C., A. Lange and T. Rutherford, 2010. Optimal emission pricing in the presence of international spillovers: decomposing leakage and terms-of-trade motives, NBER Working Paper 15899.

Brannlund, R. and L. Persson, 2012. To tax, or not to tax: preferences for climate policy attributes. Climate Policy 12, 704–721.

Bristow, A.L., M. Wardman, A.M. Zanni and P.K. Chintakayala, 2010. Public acceptability of personal carbon trading and carbon tax. Ecological Economics 69, 1824–1837.

Brouwer, R., L. Brander and P.V. Beukering, 2008. "A Convenient Truth": Air travel passengers' willingness to pay to offset their CO_2 emissions. Climatic Change 90, 299–313.

Bruvoll, A. and B.M. Larsen, 2004. Greenhouse gas emissions in Norway: Do carbon taxes work? Energy Policy, An Economic Analysis of Climate Policy: Essays in Honour of Andries Nentjes 32, 493–505.

Carattini, S., 2015. Green consumers and climate policy: Reconciling Ostrom and Nyborg, Howarth and Brekke (SSRN Scholarly Paper No. ID 2671328). Social Science Research Network.

Carattini, S., A. Baranzini and R. Lalive, 2016. Is taxing waste a waste of time? Evidence from a Supreme Court Decision (No. 227), Grantham Research Institute on Climate Change and the Environment Working Paper.

Carattini, S., A. Baranzini and J. Roca, 2015. Unconventional determinants of greenhouse gas emissions: The role of trust. Environmental Policy and Governance 25, 243–257. doi:10.1002/eet.1685

Cherry, T.L., S. Kallbekken and S. Kroll, 2014. The impact of trial runs on the acceptability of environmental taxes: experimental evidence. Resource and Energy Economics 38, 84–95.

Conte, M.N. and M.J. Kotchen, 2010. Explaining the price of voluntary carbon offsets. Climate Change Economics 01, 93–111.

Deroubaix, J.-F. and F. Lévèque, 2006. The rise and fall of French ecological tax reform: social acceptability versus political feasibility in the energy tax implementation process. Energy Policy, Social and Political Responses to Ecological Tax Reform in Europe 34, 940–949. doi:10.1016/j.enpol.2004.08.047

Drews, S., and J.C.J.M. van den Bergh, 2015. What explains public support for climate policies? A review of empirical and experimental studies. Climate Policy 1–22. doi:10.1080/14693062.2015.1058240

European Commission, 1999. The AOP II cost-effectiveness study. Technical Report August, Brussels.

Ecoplan, 2012a. Volkswirtschaftliche Auswirkungen einer ökologischen Steuerreform. Analyse mit einem berechenbaren Gleichgewichtsmodell für die Schweiz, Schlussbericht 12. September 2012, commissioned by the Swiss Federal Office of Energy, Federal Tax Administration and the Federal Finance Administration.

Ecoplan 2012b. Energiestrategie 2050 – volkswirtschaftliche Auswirkungen. Schlussbericht 12. September 2012, commissioned by the Federal Department of the Environment, Transport, Energy and Communications, Federal Office of Energy.

Federal Statistical Office, 2009. Steuerbelastung in der Schweiz. Natürliche Personen nach Gemeinden 2008. Ed.: Federal Tax Administration.

Federal Statistical Office, 2010a. Szenarien zur Bevölkerungsentwicklung der Schweiz 2010–2060.

Federal Statistical Office, 2010b. Haushaltsbudgeterhebung 2007. Kommentierte Ergebnisse und Tabellen.

Federal Statistical Office, 2011. Haushaltsbudgeterhebung 2008. Kommentierte Ergebnisse und Tabellen.

Federal Statistical Office, 2012. Haushaltsbudgeterhebung 2009. Kommentierte Ergebnisse und Tabellen.

Gallier, C., A. Löschel and B. Sturm, 2014. Did Fukushima matter? Empirical evidence of the demand for climate protection in Germany. Applied Economics Letters 21, 846–851.

Godal, O. and B. Holtsmark, 2001. Greenhouse gas taxation and the distribution of costs and benefits: the case of Norway. Energy Policy 29, 653–662.

Gowdy, J.M., 2008. Behavioral economics and climate change policy. Journal of Economic Behavior & Organization 68, 632–644.

Howarth, R.B., 2006. Optimal environmental taxes under relative consumption effects. Ecological Economics 58, 209–219.

IEA (International Energy Agency), 2010. World Energy Outlook. Paris.

IEA (International Energy Agency), 2014. World Energy Outlook. Paris.

Imhof, J., 2012. Fuel exemptions, revenue recycling, equity and efficiency: evaluating post-Kyoto policies for Switzerland. Swiss Journal of Economics and Statistics 148 (2), 197-227.

Jacobsen, G.D., 2011. The Al Gore effect: An Inconvenient Truth and voluntary carbon offsets. Journal of Environmental Economics and Management 61, 67–78.

Jordan, A.J., D. Huitema, M. Hildén, H. van Asselt, T.J. Rayner, J.J. Schoenefeld, J. Tosun, J. Forster and E.L. Boasson, 2015. Emergence of polycentric climate governance and its future prospects. Nature Climate Change.

Kallbekken, S., and M. Aasen, 2010. The demand for earmarking: results from a focus group study. Ecological Economics 69, 2183–2190.

Kallbekken, S., S. Kroll and T.L. Cherry, 2011. Do you not like Pigou, or do you not understand him? Tax aversion and revenue recycling in the lab. Journal of Environmental Economics and Management 62, 53–64.

Kallbekken, S. and H. Sælen, 2011. Public acceptance for environmental taxes: self-interest, environmental and distributional concerns. Energy Policy 39, 2966–2973.

Kirchgassner, G. and F. Schneider, 2003. On the political economy of environmental policy. Public Choice 115, 369–396.

Körber, A. and P. Kaufmann, 2007. Serie Schweizer Wirtschaftsbranchen: Bauwirtschaft – zyklische Branche mit strukturellen Problemen. Die Volkswirtschaft: das Magazin für Wirtschaftspolitik 80, 36-40.

Liang, Q.-M. and Y.-M. Wei, 2012. Distributional impacts of taxing carbon in China: results from the CEEPA model. Applied Energy 92, 545-551.

Lin, B. and X. Li, 2011. The effect of carbon tax on per capita CO_2 emissions. Energy Policy 39, 5137–5146.

Metcalf, G.E., 1999. A distributional analysis of green tax reforms. National Tax Journal 52 (4), 655-682.

Mohler, L. and D. Müller, 2012. Substitution elasticities in Swiss manufacturing. Bundesamt für Energie, Bern.

Nathani, C., D. Sutter, R. van Nieuwkoop, M. Peter, S. Kraner and R. Zandonella, 2013. Energiebezogene Differenzierung der Schweizerischen IOT 2008 und Revision der Energie-IOT 2001 und 2005. Schlussbericht 31. Mai 2013.

OECD, 1995. Climate change: economic instruments and income distribution. Organisation for Economic Co-operation and Development, Paris.

OECD, 2014. The cost of air pollution: health impacts of road transport. OECD Publishing.

OECD (undated). What are equivalence scales?. Retrieved from: http://www.oecd.org/eco/growth/OECD-Note-EquivalenceScales.pdf

Oladosu, G. and A. Rose, 2007. Income distribution impacts of climate change mitigation policy in the Susquehanna River Basin economy. Energy Economics 29 (3), 520-544.

Ostrom, E., 2009. A polycentric approach for coping with climate change. Policy Research Working Paper Series, The World Bank.

Paltsev, S., J. Reilly, H. Jacoby and J. Morris, 2009. The cost of climate policy in the United States. Energy Economics 31, 235–243.

Poterba, J., 1991. Is the gasoline tax regressive? Bradford, D. (ed.): Tax policy and the economy, Vol. 5.

Prognos, 2012a. Die Energieperspektiven für die Schweiz bis 2050. Energienachfrage und Elektrizitätsangebot in der Schweiz 2000-2050. Ergebnisse der Modellrechnungen für das Energiesystem, commissioned by Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation, Bundesamt für Energie, Basel.

Prognos 2012b. Die Energieperspektiven für die Schweiz bis 2050, Anhang III: Energienachfrage und Elektrizitätsangebot in Zahlen; Emissionen, commissioned by Federal Department of the Environment, Transport, Energy and Communications, Federal Office of Energy.

Rausch, S., G.E. Metcalf and J.M. Reilly, 2011: Distributional impacts of carbon pricing: a general equilibrium approach with micro-data for households. Energy Economics, 33, S20-S33.

Rocchi, P., M. Serrano and J. Roca, 2014. The reform of the European energy tax directive: exploring potential economic impacts in the EU27. Energy Policy 75, 341–353.

Rutherford, T., 1998. Economic equilibrium modeling with GAMS: an Introduction to GAMS/MCP and GAMS/MPSGE.

Sælen, H. and S. Kallbekken, 2011. A choice experiment on fuel taxation and earmarking in Norway. Ecological Economics 70, 2181–2190.

Sampei, Y. and M. Aoyagi-Usui, 2009. Mass-media coverage, its influence on public awareness of climate-change issues, and implications for Japan's national campaign to reduce greenhouse gas emissions. Global Environmental Change 19, 203–212.

Schneider, L. and A. Kollmuss, 2015. Perverse effects of carbon markets on HFC-23 and SF6 abatement projects in Russia. Nature Climate Change.

Spash, C.L. and A.Y. Lo, 2012. Australia's carbon tax: a sheep in wolf's clothing? The Economic and Labour Relations Review 23, 67–85.

Surchat, M., 2011. Langfristige Szenarien für das BIP der Schweiz. Die Volkswirtschaft 6 (2011), 9-12.

Sterner, T. (ed.), 2011. Fuel taxes and the poor: the distributional effects of gasoline taxation and their implications for climate policy.

Swiss Federal Office of Energy, 2009: Schweizerische Gesamtenergiestatistik 2008.

Thalmann, P., 2004. The public acceptance of green taxes: 2 million voters express their opinion. Public Choice 119, 179–217.

Tirole, J., 2012. Some political economy of global warming. Economics of Energy & Environmental Policy 1.

Vöhringer, F., 2012. Linking the Swiss emissions trading system with the EU ETS: economic effects of regulatory design alternatives. Swiss Journal of Economics and Statistics 148 (2), 167–196.

Vöhringer, F., Mathys, N. and J.-M. Grether, 2013. Trade and climate policies: do emissions from international transport matter? The World Economy 36 (3), 280–302.

Yusuf, A. A. and B. P. Resosudarmo, 2011. Is reducing subsidies on vehicle fuel equitable? A lesson from Indonesian reform experience. Sterner, T. (ed.): Fuel taxes and the poor: the distributional effects of gasoline taxation and their implications for climate policy.

Annex 1

Taxation of Emissions of Greenhouse Gases

63

Andrea Baranzini and Stefano Carattini

Contents

Abstract

In theory, carbon taxes are considered a sound instrument to curb greenhouse gas emissions. Despite its relatively scarce and recent implementation, empirical assessments of carbon taxes effectiveness are increasingly available, although they have not been surveyed yet. We fill the gap by reviewing the main studies, including indirect effects on technological development and on other pollutants (i.e., co-benefits). We also consider the supplier's response to higher expected future energy prices, surveying the principal theoretical findings and the first empirical contributions on the Green Paradox.

A. Baranzini (✉) • S. Carattini
HEG Genève – School of Management Geneva, University of Applied Sciences and Arts Western Switzerland (HES-SO), Carouge, Geneva, Switzerland
e-mail: andrea.baranzini@hesge.ch; stefano.carattini@hesge.ch

Bill Freedman (ed.), *Global Environmental Change*,
DOI 10.1007/978-94-007-5784-4_90,

Keywords

Climate policy • Carbon tax, CO_2 tax • Environmental effectiveness • Green Paradox • Co-benefits • Porter Hypothesis • Revenue recycling

JEL Classification

Q5; Q54; Q58; Q48; H23

Introduction

The United Nations (UN) Earth Summit, held in 1992 in Rio de Janeiro, oriented the international negotiations towards the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (see UN Framework Convention on Climate Change). Later on, greenhouse gas emissions were regulated for a set of industrialized countries, through the Kyoto Protocol. However, recent data indicate that CO_2 emissions, the main anthropogenic greenhouse gas, are still growing at the global level, although in some countries mitigation efforts have produced significant results. There is evidence (see, e.g., UNEP 2011) that it will be particularly difficult to decrease emissions enough to avoid an increase of global mean temperature above 2 °C preindustrial temperatures in the twentieth century, a benchmark considered by many as necessary to avoid very costly adaptation (see, e.g., EU Climate Change Expert Group 2008). Hence, more efforts are needed to curb the global level of emissions and tackle climate change. Often, carbon taxes have been advocated by economists as an effective and potentially efficient instrument for reducing greenhouse gas emissions. However, their application in the real world remains relatively seldom. Only recently, several countries have implemented taxes based on carbon or CO_2 content, with of course wide differences in the design, the tax rate, and the targeted products. Presently, we are aware of 11 countries having implemented a carbon/CO_2 tax (Australia, Denmark, Finland, Ireland, Latvia, the Netherlands, Norway, Slovenia, Sweden, and Switzerland). The precursors were the European Nordic countries, with Finland as the first country introducing a tax explicitly targeting CO_2 in 1990.

In this paper, we concentrate on the environmental impact of carbon taxes. Of course, carbon taxes can be assessed based on other criteria, such as their impact on households, on competitiveness, or on growth (see, e.g., Baranzini et al. 2000). The structure of the paper is the following. Section"What Kind of Emission Taxes?" discusses the main practical characteristics of carbon taxes. Section "Environmental Impacts" analyzes the environmental performance of carbon taxes, by highlighting their impact on technology, overall emission path, and emissions of other pollutants. Section "Summary and Conclusions" summarizes and concludes.

Definition

Economic instruments used in climate policies can be divided into price or quantity instruments. Emission trading programs are quantity instruments, since the initial amount of permits corresponds to the emission target. Permit trading in organized markets or by individual negotiation determines then their price. With emission taxes, the environmental authority administratively determines the price of emissions, and then emitters adapt their behavior. Therefore, emission trading programs determine with certainty the amount of emissions (provided that full compliance is ensured), while the price paid by emitters is unknown a priori and it changes depending on market conditions. With emission taxes, the cost to emitters is known and stable, while emissions are a priori unknown and change based on technological conditions (e.g., variations in abatement costs), number of emitters, and general macroeconomic situation. Those uncertainties determine the economic efficiency of the instrument, as discussed in the seminal paper by Weitzman (1974) and applied in the climate policy context by Pizer (2002).

Since climate change is a global environmental problem, in theory, an emission tax has to cover each emitter and to impose a charge per unit of greenhouse gas released, which equates marginal abatement costs worldwide (for a conceptual discussion of global environmental taxes, see, e.g., Thalmann 2012). It could even be coupled with a sequestration tax credit, to take advantage of sometimes lower abatement costs in forestry. To achieve economic efficiency, the tax rate has to correspond to the marginal external costs from climate change, at the optimal abatement level ("Pigouvian" tax). Rising costs of damages from the accumulation of CO_2 concentration in the atmosphere would thus imply an increasing tax rate over time. Since efficiency is reached with this tax design, the use of the generated fiscal revenues is completely independent from the climate target and can thus be used for other purposes. However, in practice, emission taxes are often conceived far away from the theoretically ideal design. Moreover, the use of generated fiscal revenues (i.e., revenue recycling) may affect the acceptability of emission taxes. Of course, the farther away from theoretical considerations, the least the tax is efficient and cost- and environmentally effective. In what follows, we briefly discuss the basic features defining emission taxes in practice, i.e., the tax base, objective and tax rate, exemptions, and revenue recycling.

The tax base defines different types of emission taxes. We are unaware neither of a tax whose base is greenhouse gas emissions nor of an international emission tax. Therefore, the emission tax closer to the theoretical model is a carbon or CO_2 tax, applied at the national level. A *carbon tax* is a charge to be paid on each energy vector, proportional to the quantity of carbon emitted when it is burned. A *CO_2 tax* is a unit tax, specified per ton of CO_2 emitted. It can easily be translated into a carbon tax, by knowing that a ton of carbon corresponds to 3.67 t of CO_2.

In addition to emission taxes, there are other taxes that affect emissions. In particular, an *energy tax* depends on the quantity of energy consumed and is

specified in some common unit (like in barrels of oil equivalent or in British thermal units, BTU) measuring the energy content of fuel. Therefore, contrary to a carbon or CO_2 tax, an energy tax also covers nuclear and renewable energy, unless they are exempted. Moreover, since oil and gas have greater heat contents for a given amount of CO_2 emissions compared to coal, an energy tax implies a greater charge on oil and gas than a carbon tax. Other existing taxes are charged to specific energy products and have an impact on emissions, but their tax base is smaller and the tax rate is on the physical quantity of the product (e.g., on € per liter). Nordhaus (2010) proposed an international tax on fossil fuel consumption. In the same vein, although often for reasons unrelated to climate policies, several countries possess gasoline taxes and taxes on energy sales (excise duties), sometimes per unit, other ad valorem. Therefore, countries implicitly tax greenhouse gas emissions, even in the absence of explicit emissions taxes. Of course, the smaller the tax base compared to the sources of greenhouse gases, the lower the impact on emissions, for a given tax rate.

Another feature determining the performance of emission taxes is its objective, which then contributes in determining the tax rate. Since marginal climate change external costs are difficult to assess, the optimal abatement target cannot be determined and thus true Pigouvian taxes are not implemented (see Baumol and Oates 1971). Given that emission taxes distribute abatement efforts depending on marginal abatement costs, they can be used to achieve a given abatement target at the lowest global cost (cost-effectiveness). If this is the objective, then the tax rate has to be set high enough to modify emitters' behavior so that the emission target is reached. However, since abatement costs are not known by the environmental authority, recent legislations generally set a maximum tax rate and then let the authority modify it depending whether the emission target is achieved or not. The tax rate has then to be continuously adjusted, in particular to account for changes in the number of emitters, energy efficiency improvements, changing possibilities for fuel substitution, and availability and cost of backstop technologies. The cost-effectiveness approach has the advantage that it requires only cost-minimizing firms and does not need strong assumptions such as profit maximizing and perfectly competitive firms, i.e., it applies to more realistic conditions.

Instead of cost-effectiveness, sometimes the stated objective of the emission tax is purely financial, i.e., to collect an amount of money that can then be used to finance abatement activities. This approach is of course not cost-effective, but can be more politically acceptable. Some countries proposed, for instance, to implement an international CO_2 tax with a relatively low rate, but whose receipt could be used to finance mitigation and adaptation measures (e.g., see the Swiss proposal at the Bali Conference).

The tax rate level is influenced by the emission tax objective but also by possible exemptions granted to some emitters. Of course, for a given abatement or fiscal target, more exemptions mean higher tax rates for submitted emitters. Exemptions or tax rebates may be granted to some firms or sectors because of competitiveness fears, e.g., export-oriented or relatively mobile firms. Low-income households

could also be exempted or submitted to a lower tax rate, although it would be administratively more cumbersome. Even though those considerations could decrease relocation of economic activities or be justified for distributive reasons, exemptions are not the most cost-effective mean to reach a given abatement target. Indeed, cost-effectiveness demands a unique carbon price to all emitters. Competitiveness or distributional concerns are thus more effectively treated by using the generated fiscal revenues or a set of complementary policies (e.g., social cushioning, carbon-motivated border tax adjustments).

From our discussion above, we observe that the management of the generated fiscal revenues is central in many aspects of carbon tax implementation. There are four main ways to use the generated fiscal revenues: earmarking to a specific activity (environmental or not), redistribution to an economic agent (household or firm), reduction of another tax (e.g., on labor or on capital), and not earmarked, i.e., to the general budget. Depending on use, the generated fiscal revenues could thus increase acceptability and environmental effectiveness, decrease distributive impacts, or even reduce inefficiencies in the general fiscal system.

Environmental Impacts

General Considerations

This section surveys the environmental impacts of existing emission taxes. We are thus not presenting ex ante studies which are used, e.g., to determine the tax rate necessary to achieve a given emission target or to simulate the impacts of a hypothetical emission tax. In addition, we focus mainly on empirical analyses based on real data, because ex post studies that assess the impact of emission taxes through simulations of the "counterfactual" (the level of emissions that would have been achieved without taxes) should be considered with caution (see below). The assessment of environmental performance has to account for the induced emission abatements in the short term, but also the more indirect longer-term impact of emission taxes, through, e.g., the associated technological changes and firms' adaptation to new incentives. Moreover, it is necessary to consider three additional dimensions. First, emission taxes reduce other pollutants, in addition to greenhouse gases. Therefore, there are supplementary benefits associated with emission taxes ("secondary or co-benefits"). Second, since there is no worldwide emissions tax, a carbon tax implemented in a country influences trade flows or encourages activities to relocate and thus increase emissions in other regions ("geographical carbon leakage"). As a result, the net impact of the tax on global carbon emissions may be lower (see, e.g., De Melo and Mathys 2010 for a detailed survey). Third, climate policy may have an impact on the extraction path of resource owners, eventually leading to a different timing of emissions ("inter-temporal carbon leakage"; see the "Green Paradox" in section "Counterproductive Carbon Taxes? The Green Paradox" below). In addition to those dimensions, we note that the practical features of implemented emission taxes make it difficult to

precisely assess their impact. Indeed, they are often only one instrument in a package of policy measures aimed at reducing emissions. Their implemented design is often difficult to model, since they possess several exemptions and exceptions, in particular to energy-intensive industries or to industries facing international competition. Moreover, they are often part of a general fiscal reform, which replaces other taxes on energy and reduces the share of traditional taxes (e.g., on labor and capital). Finally, the generated fiscal revenues may be used to finance abatement activities and technologies or environmental projects.

Assessment of Emission Reductions

Supply and demand price elasticities are central in the environmental effectiveness of emission taxes, because they determine emitters' behavioral changes. Suppliers' response can eventually lead to "inter-temporal carbon leakage," i.e., the displacement of emissions through time. In addition, the point of imposition, the entry of new polluters, tax exemptions, and the use of the generated fiscal revenues are other factors contributing to the environmental performance. As noted by Baranzini et al. (2000), there are several methodological difficulties to assess the specific features of implemented emission taxes and to consider the different dimensions determining the empirical assessment of their environmental impacts. It is thus not surprising that the majority of studies in the literature base their conclusions on projections from scenarios, based on either top-down or bottom-up studies. The meta-analysis of Patuelli et al. (2005) reviewed specifically this literature, but related to the impact of environmental tax reforms more in general. By analyzing 61 studies comprising a total of 186 simulations, Patuelli et al. (2005) find that the studies projected an average CO_2 reduction of 9.7 % due to environmental tax reforms, with studies in a short-term frame showing an impact of 6 %, while those in a longer term about 13 %, with notable differences depending on regions. As anticipated, those results have to be interpreted with caution, since in several studies the emission reduction levels are chosen a priori. In addition, econometric simulations suffer a series of other drawbacks (for a discussion, see, e.g., Speck et al. 2006; Andersen 2010. Furthermore, the scope of meta-analyses can be limited by the comparability of taxes in terms of design and size.

Only a few studies use an empirical approach based on real data. Among them, Lin and Li (2011) deal with methodological issues and in particular with endogeneity (endogeneity may lead to biased results and has thus to be accounted for. In our context, the main source of endogeneity is the reverse causality between policy and emissions. Estimations of the impacts of a climate policy on emissions have to consider that higher levels of emissions may lead to more stringent policies). They use a difference-in-difference approach to compare the emissions per capita of Denmark, Finland, Sweden, the Netherlands, and Norway, before and after the introduction of a carbon tax. As a control group, they used similar European economies, but which have not implemented carbon taxes. They find

a significant effect of carbon taxation for Finland only, whose impact corresponds to a reduction of 1.7 % in the growth rate of CO_2 per capita, compared with the case in which the countries would have followed an emission path without carbon tax, as in the control group. According to Lin and Li (2011), the nonstatistically significant result for the other countries is mainly due to the important tax exemptions to energy-intensive sectors. This analysis is partly corroborated by Bruvoll and Larsen (2004), who analyze the impact of carbon taxes on CO_2 emissions in Norway, over the period 1990–1999. Norway is a country with relatively high-carbon tax rates in some specific sectors (e.g., US$ 51/t CO_2 for gasoline in 1999), but several activities are submitted to lower rates or exempted (e.g., cement production). The authors use a multisectoral model to compare emissions with (based on real data) and without carbon taxes ("the counterfactual"). They find that carbon taxes reduce emissions by 2.3 %, mainly through an increase in energy efficiency and change in energy mix, while impact on scale is negligible. Given the relative high tax rates, the authors maintain that the impact would have been much greater, if emissions in sectors expected to be great contributors to emissions were not exempted. For the same country, Godal and Holtsmark (2001) show that the exempted sectors would face an average decline in operating profits from 17 % to 22 % if the privileged CO_2 exemption regime would end. The Norwegian failure to extend the tax base to the exempted industries shows that increasing the level of existing taxes on emissions may be politically more feasible than including additional emission sources. If the goal is to achieve an emission abatement target cost-effectively, the lesson may thus be to start with low taxes and a broad taxation base rather than high taxes on some sectors and complete exemptions on others (Godal and Holtsmark 2001). Of course, for the tax to be environmentally effective, all the submitted sectors have to be sensitive to energy prices. Indeed, in a study on a panel of (mainly) energy-intensive industries in Denmark, Norway, and Sweden, Enevoldsen et al. (2007) show that with the exception of natural gas and electricity (whose long-term elasticity is between −0.10 and −0.28 in the three countries), all energy inputs are to a significant extent sensitive to energy/carbon taxes (elasticity between −0.42 and −0.62). Given the low tax elasticity of electricity, the authors encourage policymakers to target the electricity mix and to reduce the relative carbon content. Moreover, cross-price elasticities show some evidence of substitution between coal or oil and electricity. Considering broader input aggregates, Enevoldsen et al. (2007) find that the energy input has a tax elasticity in the range of −0.35 to −0.44 for the three countries. This implies that energy/carbon taxes not only affect the energy mix but also decrease energy consumption. In addition, the study finds positive cross-price elasticity between labor and energy, which means that energy/carbon taxes induce a switch from energy-intensive to labor-intensive sectors (see e.g., EEA 2011a).

Concerning the impact of existing product taxes on emissions, there is a huge but more general literature on price elasticity of gasoline consumption (vs. emissions). A number of surveys provide summaries of results on gasoline demand elasticities, such as Graham and Glaister (2002). These traditional literature surveys are complemented by meta-analyses. Brons et al. (2008) perform a meta-analysis on

a dataset composed by 312 elasticity estimates from 43 primary studies. The estimates of the short-run price elasticity of gasoline demand fall between −1.36 and −0.37 and are in general lower in absolute value than the long-run estimates, which fall between −2.04 and −0.12. The mean price elasticity of gasoline demand is −0.34 in the short run and −0.84 in the long run. Brons et al. (2008) also identify the characteristics driving different results. They show in particular that the USA, Canada, and Australia display a lower price elasticity, that price elasticity increases over time, and that time-series studies and models with dynamic specification report lower elasticity estimates (in absolute value) than the general sample. Generally, price elasticities are lower than the corresponding values of income elasticities both in the short and in the long run (see Graham and Glaister 2002; Sterner 2007). Applied to emission taxes, this would imply that the (real) tax rate would have to grow faster than income, to offset the increase in consumption due to an income growth (but this could lead to a "Green Paradox"; see below). Compared to other policy instruments, Austin and Dinan (2005) show that fuel taxes are superior to standards, because they allow for both short-term (e.g., driving less) and long-term adjustments (e.g., replacing the vehicles fleet) (see also Sterner 2007). More recent works address specifically the impact of taxes on gasoline consumption and, in some cases, on emissions. Results of this literature point out that carbon taxes could have a specific impact on emissions. For instance, Davis and Kilian (2011) use a range of econometric techniques to assess the potential impact that a carbon tax could have in the USA, by estimating the impact of past variations in gasoline tax. They note that the resulting reductions in carbon emissions may not grow proportionately as linear econometric models predict and that tax elasticity is much larger than price elasticity, maybe because the price variations due to the tax are perceived as more permanent by consumers. According to their preferred model, a 10-cent increase in gasoline tax would imply a short-term reduction in US carbon emissions of about 0.5 %. The fact that consumers' reaction depends on the source of price variation is a consistent finding in the literature. For instance, Baranzini and Weber (2013) find that in Switzerland an increase in the existing mineral oil tax decreased gasoline demand by about 3.5 %. Therefore, this study shows that an increase in the tax has two distinct impacts, both of which decrease demand: first, the price increase itself, then an additional reaction by consumers, who know that this price increase is not a natural variation resulting from market forces. Ghalwash (2007) obtains differentiated impacts, but his results on different types of goods are somewhat ambiguous. Li et al. (2012) find a much larger effect of tax increase with respect to price increase and point to an interesting explanation: because gasoline tax changes are subject to public debates and attract a great deal of attention from the media, this could contribute to reinforce consumers' reaction. Scott (2012) finally finds consumers to be twice as responsive to tax-driven price changes as to market-driven price changes. In an experimental framework, Goeschl and Perino (2012) show however that taxes can crowd out agent's intrinsic motivation. Nevertheless, it should be noted that in their framework, tax revenues are neither allocated to more abatement efforts nor redistributed.

Environmental Impacts of Technological Development

The literature reviewed by EEA (2011b) shows that price-based policy instruments have in general a positive impact on eco-innovation, although this effect is not universal. A carbon tax is expected to stimulate the production of clean technology, because it modifies the price differential between the use of high-carbon and low-carbon technologies. This literature sometimes refers to the "Porter Hypothesis," from Porter (1991) and Porter and van der Linde (1995), in which the authors outline the hypothesis that stricter environmental regulations could help a country more than harming it, by fostering technological innovation and provoking a first-mover advantage (strong version). In our context, we do not consider the impact on international competitiveness of a carbon tax, as this topic is beyond the scope of this paper (for a survey, see, e.g., Zhang and Baranzini 2004). However, we do consider in this section induced technological innovation, and hence, we consider the weak (Hicksian) form of the Porter Hypothesis (see Jaffe and Palmer 1997) (for a short introduction to the general Porter Hypothesis' theoretical bases, including the narrow and strong version, see, e.g., Jaffe et al. (2005), Krysiak (2011), Lanoie et al. (2011), and Costantini and Mazzanti (2012); for another survey including empirical studies, see Ambec et al. (2013)).

Studies assessing empirically the technological impact of emission taxes or environmental regulations often use patents as a proxy for technological change in a particular sector (see EEA 2011b), whereas they measure total factor productivity to identify an effect affecting the whole economy, as those proxies seem to have a good fit with respect to the unobservable technological improvement.

Commins et al. (2011) analyze the impact of energy taxes (and the European Union Emissions Trading System, from 2005 on) on a panel of European firms over the period 1996–2007. Despite a large inter-sectoral variation, the results show that energy taxes lead to an average net increase in total factor productivity. They conclude by saying that "this finding supports the Porter Hypothesis. Regulation spurs innovation." Of course, not only emission taxes are expected to spur technological innovation. For instance, analyzing seven European countries over the period 1989–2004, Noailly (2012) shows that more demanding standards increase patents in energy efficiency in the building sector, whereas higher energy prices do not. The author gives two explanations for the latter result. First, real energy prices are generally very low over the observed period. Second, the building sector faces an important principal-agent problem, perhaps leading to lower sensitivity to economic incentives. Similarly, Jaffe and Palmer (1997) find that in the USA, increasing environmental compliance expenditures leads to higher total R&D expenditures, with a lag. However, they do not find a direct impact on domestic successful patent applications. This result was already obtained by Jaffe and Stavins (1994), who assess the technology diffusion in energy efficiency technologies following a change in energy prices, based on US data from 1979 to 1988. The authors extrapolate their result to the case of energy taxes, which would lead to an increase in energy prices. Newell et al. (1999) find a similar result

with a large set of US data from the 1960s to the 1990s: changes in energy prices (as well as in efficiency standards) induce technological innovation in product characteristics.

Using US data from 1970 to 1994, Popp (2002) computes an energy-price elasticity of technology, the latter defined as the share of energy patent applications relative to all applications. Controlling for the stock of knowledge using patent citations, he finds an elasticity of 0.06 in the short term.

Applying a similar approach, using European data (EU15) from 1996 to 2007, Costantini and Mazzanti (2012) find a positive link between environmental and energy policy (measured through tax revenues) and the export dynamics of high-technological firms (the result partly applies also to medium-low-tech firms). The effect on exports, not technology itself, is relatively large, with elasticities ranging from 0.024 to 0.038, depending on the type of taxation, and does not apply to green sectors only.

Several studies (Arimura et al. 2007; Johnstone and Labonne 2006; Darnall et al. (2007), Lanoie et al. 2011) used a business' self-reporting database including 4,200 facilities distributed among seven OECD countries (Canada, France, Germany, Hungary, Japan, Norway, and the USA). Lanoie et al. (2011) test the three versions of the Porter Hypothesis and show that perceiving high environmental policy stringency has a positive effect on environmental R&D expenditure, but no impact on total R&D. Keeping stringency constant, the authors try to identify some instrument-specific effects (e.g., of taxes) and report that only medium and high performance standards have a positive effect.

The issue of policy stringency is further analyzed by Brunnermeier and Cohen (2003) on a sample of 146 industries over the period 1983–1992. They obtain that pollution abatement expenditures (a *proxy* for policy stringency) do affect patents, but that monitoring and enforcement (measured as the number of inspections) do not. Hence, it seems that the announcement of policy tightening suffices to induce technological change (signal effect).

However, the impact of environmental policy on technological innovation and diffusion should also be assessed outside the country implementing the climate policy. Recent theoretical literature discusses the conditions under which trade spills over technological change and impacts carbon emissions; see, for instance, Di Maria and van der Werf (2010), Golombek and Hoel (2004), or Acemoglu et al. (2012). Lanjouw and Mody (1996) first outline the link between environmental regulation in a given country (*proxied* by pollution control expenditures) and innovation in another. Based on a qualitative study, the authors analyze German, Japanese, and US patents from the 1970s to the end of the 1980s, coupled with observations from a series of low- and middle-income countries. Among developed countries, the authors find that most domestic policies stimulate patent production also in the two other countries, although the strongest impact is within the country. Moreover, they find that developing countries enjoy the inventions of developed countries and concentrate their efforts mainly on adaptive innovation, i.e., adapting existing technologies and patenting for local markets (but not for exports). In the same vein, Barker et al. (2007b) apply an ex post dynamic econometric analysis

using cointegration techniques and find that the environmental tax reforms implemented in some European countries (Denmark, Finland, Germany, the Netherlands, Sweden, and the UK) lead to a very small geographical carbon leakage to the EU's non-ETR countries, because technological innovations cross borders to non-ETR EU countries, the latter thus enjoying positive spillovers. Di Maria and van der Werf (2010) posit even the basis for a net *halo*, i.e., negative carbon leakage. However, the result of Barker et al. (2007b), Lanjouw and Mody (1996), and the others needs to be confirmed by additional empirical evidence. For instance, Popp (2006), in a study on patent reactions to NO_x and SO_2 policies in Germany, Japan, and the USA over 1979–2003, cannot find a direct link between domestic environmental regulation and patenting in foreign countries, i.e., inventions respond to domestic but not to foreign policy. Follower countries do not seem to enjoy technology transfers by applying the innovations developed by the forerunners, but they rather develop their own. However, Popp (2006) does find an indirect impact represented by a transfer of knowledge, measured by cross-country patent citations. Hence, latecomers still enjoy some spillovers but knowledge-related instead of technology-related.

A final remark concerns the rebound effect associated to technological change, i.e., technologies can favor clean energy (and thus a decline in emissions) but also reduce the real cost of energy services per unit, thus leading to an increase in emissions. Hence, the net effect of eco-innovation could be theoretically ambiguous. Since aggregate empirical estimations are assessing the total change in emissions resulting from emission taxes or technology changes, the rebound effect is implicitly accounted for in the final result. On the contrary, the rebound effect has to be explicitly modeled in simulation studies or general equilibrium models. The importance of the rebound effect is subject to debate. Some authors like Brännlund et al. (2007) find that in Sweden, an increase in energy efficiency of 20 % augments CO_2 emissions by approximately 5 %. In this case, technological change is thus increasing emissions. By considering capital costs explicitly, other studies like Mizobuchi (2008) find for Japan a lower rebound effect of 27 %, which means that actual emission reductions due to technological change are 73 % of the engineering potential. The macroeconomic simulation of Barker et al. (2007a) for the UK economy leads to a similar result, with a rebound effect of approximately 15 %. In these cases, technological improvements have thus a net abatement impact on emissions, in line with Lin and Li (2011).

Counterproductive Carbon Taxes? The Green Paradox

Reminiscent of exhaustible resource theory and starting in particular from Sinclair (1992), new theoretical contributions introduce more explicitly the supply side of the market in the assessment of the environmental effectiveness of carbon taxes. Sinn (2008) shows that more stringent climate policy could not only lead to a geographical dislocation of emissions but also to their temporal displacement ("temporal carbon leakage"). Indeed, if future climate policies are expected to be

more stringent than those currently in place, wealth-maximizing resource suppliers can anticipate a depression in their revenues and thus anticipate the extraction of those resources. If this effect is so strong so that the net effect on damages is positive, a climate policy could even exacerbate the climate issue. This is the so-called Green Paradox.

Following Gerlagh (2011), there are two versions of the Green Paradox. The weak version is a short-term phenomenon and is represented by the case when, following a climate policy, resource owners anticipate the timing of extraction, thus increasing current emissions. However, given the long-lasting effects of emissions in the atmosphere, climate policies have to consider cumulative emissions and their damages. If emissions increase today, but they decrease sufficiently tomorrow, climate change is then less severe and we face a weak Green Paradox (see Gerlagh 2011; Habermacher and Kirchgässner 2011). A strong Green Paradox implies instead that the climate policy modifies the anticipations of resource owners such that the resulting cumulative extraction corresponds to larger environmental damages.

Gerlagh (2011) does not analyze an explicit climate policy, but refers to a backstop technology. Under some conditions, he finds a weak and a strong paradox. However, when relaxing the assumptions regarding the perfect substitutability between limited resources and the backstop technology and introducing an increasing marginal cost in the backstop technology, Gerlagh (2011) does not obtain a Green Paradox (see also Hoel 2010). Sinn (2008) notes that time-invariant unit taxes on carbon extraction would lead to a flattening of the carbon supply, thus avoiding a temporal carbon leakage. However, since resource-owner countries are likely to be against this policy, Sinn (2008) proposes instead a worldwide system of emission trading, in which oil-importing countries would act as a monopsony, thus constraining the suppliers' inter-temporal maximization. Habermacher and Kirchgässner (2011) expand Sinn's (2008) model by introducing additional climate measures such as alternative carbon taxes and peculiarities such as backstop technologies, global fuel demand cartels, and carbon capture and storage systems. Their model reverses the outcome, since with both competitive and monopolistic resource suppliers (see e.g., OPEC), the net present value of cumulative emissions decreases with a carbon tax once taking into account future carbon measures, i.e., there is no evidence of a strong Green Paradox. Fischer and Salant (2012) obtain a similar result, but find evidence in favor of the weak version, i.e., in their model, there is inter-temporal carbon leakage due to climate policies. Interestingly, they note that a relatively more stringent policy is likely to lead to lower inter-temporal carbon leakage, i.e., the simulations accounting for rent adjustment converge to those that omit the possibility of carbon leakage. That is why Fischer and Salant (2012) advocate for ambitious policy reducing inter-temporal carbon leakage.

Using a Pareto optimality approach as in Sinn (2008), and not a utilitarian approach as often done in the literature, Spinesi (2012) shows that increasing subsidy to R&D expenditures in the field of fossil fuels could also avoid both the weak and the strong Green Paradox. Indeed, greater subsidies could counter the

reduction in resource-owners' profits due to an increasingly strong climate policy (in this case a higher carbon tax). This result is valid with both perfect and imperfect competition in the suppliers market, similarly to Habermacher and Kirchgässner (2011). However, subsidizing fossil fuel production could raise distributive issues since it could create additional rents for monopolistic firms. Moreover, other contributions on the optimal path of emissions suggest exactly the opposite, i.e., coupling carbon taxes with (temporary) research subsidies in the clean sectors.

Empirical assessments of the Green Paradox are extremely rare as we are aware of one study only, in addition not specific to climate policy. Di Maria et al. (2013) find a substantial drop in the price of coal deliveries to US (coal-fired) power plants between a program announcement capping SO_2 emissions in 1991, and its implementation in 1995, especially for high-sulfur coal. This finding is in line with theory, since we expect coal producers to increase their supply prior to introduction of the cap. However, the evidence on the Green Paradox itself, which focuses on the emission trajectory, is rather mixed. Indeed, the price drop is not transferred to an overall change in quantities or on the quality of coal (i.e., the sulfur intensity). Plants seem to start early adapting to the new regulation by reducing the sulfur content ahead of schedule. Only those not constrained by long-term contracts take advantage of lower spot prices, in line with theory. Hence, this paper concludes that a Green Paradox does not automatically rise in anticipation of a tighter regulation. We recall that the theoretical background predicts that supplier's response may lead to a Green Paradox, under given circumstances, but that proper policy design matters. Following Di Maria et al. (2013), we emphasize two factors against the rise of a Green Paradox. First, coal demand from power plants appears to be quite inelastic. Actually, it seems that long-term contracts play an important role and that a short implementation lag (4 years in this case) leads to a prolonged period of coal sales but not all plants can take advantage of such window of opportunity, due to capacity constraints and other sources of short-term inflexibility. Second, overlapping environmental regulations may limit the risk of a Green Paradox. The lesson applicable to climate policy is that it is possible to avoid a Green Paradox by introducing as soon as possible stricter regulations in view of the 2020's new Kyoto agreement abatement goal. In any case, announcing the objectives early and postponing policies later is the worst solution.

Summarizing, the intuition of the Green Paradox extends our knowledge of the impacts of climate policies, in particular allowing resource supply to be endogenously determined. However, the theoretical literature on the Green Paradox does not suggest that policymakers should not implement climate policies to avoid counterproductive effects. On the contrary, the literature indicates that the strong version can be avoided if policymakers carry on their climate policies taking into account the reaction of resource owners. Moreover, this reaction is generally modeled also in the case of reduced competition, a theoretical framework that characterizes the market of many natural resources, e.g., oil. Empirical assessments of the Green Paradox are currently very rare, because the largest part of the theoretical literature is very recent and also because of challenging empirical issues related to endogeneity and information on policy expectations.

The Co-Benefits of Emission Taxes and Carbon Policies

In addition to greenhouse gases, climate policies may have an impact on other pollutants. In theory, those impacts can be positive or negative. For instance, a policy targeting CO_2 abatement can decrease SO_2 emissions, by leading to a switch from oil to natural gas. That is, CO_2 and SO_2 are in this case complements and spillovers are positive. However, the same policy may lead to a higher combustion temperature of natural gas, creating more emissions of NO_X. That is, CO_2 and NO_X are in this case substitutes, but spillovers can be either positive or negative, depending on the output effect, e.g., if less natural gas is used overall (Holland 2011). However, there is a general consensus that positive spillovers substantially overweigh negative externalities. That is why the literature talks about co-benefits, secondary or ancillary benefits. We use the IPCC's (2007) definition of co-benefits, illustrating the importance of an integrated approach that considers additional benefits as important as direct benefits.

OECD (2002) presents a long list of beneficial effects induced by emission abating policies. It includes lower mortality and morbidity from lower local air pollution, better visibility, higher crop yields, less damages to structures due to less acid rain, and reduced urban congestion, noise, and accidents. Indoor pollution matters mainly for developing countries (OECD 2009). According to OECD (2002), ecological benefits should also be included, because tropical forests are important for the conservation of flora and fauna.

Most of these benefits are local and arise in the short term, which could contribute to increase the acceptability of climate policies (see OECD 2002). Pittel and Rübbelke (2008) show with a simple game-theoretical setting that international negotiations would be favored if the player's payoff would include co-benefits, reducing the free-riding problem. Moreover, there is some evidence outlying that co-benefits are likely to be higher in emerging economies than in developed countries. That is, Pittel and Rübbelke (2008) show that accounting for exclusive and immediate local benefits increases the payoffs of a developing country's cooperative attitude.

An important issue in this literature is represented by the valuation of co-benefits in monetary terms, in particular because many studies focus on the health impacts of reduced air pollution, which typically represent the largest component of co-benefits. But the value of statistical life is a controversial approach, with considerable political sensitivity (see OECD 2002, 2009).

An additional methodological issue is the determination of the baseline scenario, i.e., the case wherein the climate policy is not implemented. For instance, projected changes in standards for air pollutants have to be considered (OECD 2002). Moreover, simulations should consider both the opportunity cost of investing in another policy targeting local pollutants instead of a carbon policy and the reduced administrative burden deriving from the co-benefits of a single policy on different fields of regulation (OECD 2009). Furthermore, model calibration is not neutral. For instance, the determination of the social discount rate is very likely to affect the final results, as well as other underlying assumptions. For example, a nonlinear relation between air pollution and health makes more sense than a linear assumption (OECD 2009).

Due to all these issues, estimations of co-benefits are not very consistent across studies. According to OECD (2002), they range from 30 % to 100 % of abatement costs, with lower estimates in more recent studies. Furthermore, empirical estimates are likely to underestimate the effect of co-benefits, since it is particularly demanding to take into account all spillovers. Therefore, studies generally focus on the main co-benefits only.

Ekins (1996) surveys the estimated co-benefits for a series of developed countries (the USA, the UK, Germany, Norway, and European countries in general) and finds a very large range of values from US$21 per ton of carbon up to US$794, with an average co-benefits per ton of carbon of US$273. OECD (2002) reviews 13 studies and finds that estimates depend on the scope of the analysis (i.e., how many co-benefits and how many sectors are analyzed) and on the country. When results are monetized, they range from US$3 to US$452 per ton of carbon. More recently, OECD (2009) surveyed 9 studies focusing on different cases in terms of country of interest, horizon, pollutants, co-benefits, and model assumptions. When results are monetized, they range from about US$14 to $58 per ton of carbon.

Nemet et al. (2010) review 37 studies on air-quality-related co-benefits providing 48 monetary estimates, 28 relative to developed countries and 20 for developing countries. Although comparability between studies with different architecture is not always ensured, Nemet et al. (2010) confirm that recent analysis tends to be more conservative and that in general estimates for developing countries are higher than for developed countries. The median (mean) for developed countries is US$31 (US$44) per ton of CO_2 and US$43 (US$81) for developing countries. A possible explanation for higher co-benefits in developing countries is their higher levels of air pollution and thus larger health benefits from abatement, assuming a nonlinear relation between pollution and health effects.

Groosman et al. (2011) analyze the transport and electric power sectors in the USA, ending up with estimates for co-benefits over the period 2010–2030 ranging from US$1 to US$77 per ton of CO_2. Estimates are sensitive to modeling assumptions and years, with co-benefits at the end of the period being many times larger than in 2010. The authors present 4 scenarios, modifying the underlying assumptions and in particular mortality response to pollution exposure, capped SO_2 emissions, and the social discount rate. Interestingly, the authors find that marginal co-benefits exceed marginal abatement cost for 2 scenarios over 4. Omission of co-benefits would thus substantially underestimate the benefits of a climate policy using, e.g., carbon taxes.

Summary and Conclusions

Carbon taxes political acceptability is a major concern, which may explain why in practice only few countries have implemented them. Major issues range from distributive consequences to administrative burden and competitive impacts. In this paper, we discuss specifically the concern regarding their environmental effectiveness. In the literature, the environmental performance is often evaluated through ex ante simulations based on disputable assumptions. In this paper, after

reviewing the main characteristics of carbon taxes, we discuss their environmental impacts mainly based on empirical estimations using real data. We highlight several factors determining emissions, such as technological innovation, the complementary decrease of other pollutants (co-benefits), and the reaction of suppliers (the Green Paradox). We stress that climate policy should be considered from an integrated perspective and that the full potential of carbon taxes can be assessed only with a comprehensive approach which includes all aspects related to the implementation of this instrument. When carbon taxes are evaluated in this multifaceted way, rationales for implementation tend to increase rather than decline.

Acknowledgments We thank Nicole A. Mathys, Stefan Speck and Philippe Thalmann for very useful comments and suggestions on an earlier version of this paper.

References

Acemoglu D, Aghion P, Bursztyn L, Hemous D (2012) The environment and directed technical change. Am Econ Rev 102(1):131–166

Ambec S, Cohen MA, Elgie S, Lanoie P (2013) The Porter Hypothesis at 20: can environmental regulation enhance innovation and competitiveness? Rev Environ Econ Policy 7:2–22

Andersen MS (2010) Europe's experience with carbon-energy taxation. *S.A.P.I.E.N.S.* http://sapiens.revues.org/1072

Arimura T, Hibiki A, Johnstone N (2007) An empirical study of environmental R&D: what encourages facilities to be environmentally innovative? In: Johnstone N (ed) Corporate behavior and environmental policy. Edward Elgar/OECD. http://www.oecdbookshop.org/display.asp?K=5L4THQBS3NTD&LANG=EN

Austin DH, Dinan T (2005) Clearing the air: the costs and consequences of higher CAFE standards and increased gasoline taxes. J Environ Econ Manag 50:562–582

Baranzini A, Goldemberg J, Speck S (2000) A future for carbon taxes. Ecol Econ 32(3):395–412

Baranzini A, Weber S (2013) Elasticities of gasoline demand in Switzerland. Energy Policy 63:674–680

Barker T, Ekins P, Foxon T (2007a) The macro-economic rebound effect and the UK economy. Energy Policy 35:4935–4946

Barker T, Junankar S, Pollitt H, Summerton P (2007b) Carbon leakage from unilateral environmental tax reforms in Europe, 1995–2005. Energy Policy 35:6281–6292

Baumol WJ, Oates WE (1971) The use of standards and prices for protection of the environment. Swed J Econ 73:42–54

Brännlund R et al (2007) Increased energy efficiency and the rebound effect: effects on consumption and emissions. Energy Econ 29:1–17

Brons M, Nijkamp P, Pels E, Rietveld P (2008) A meta-analysis of the price elasticity of gasoline demand. A SUR approach. Energy Econ 30(5):2105–2122

Brunnermeier SB, Cohen MA (2003) Determinants of environmental innovation in US manufacturing industries. J Environ Econ Manag 45:278–293

Bruvoll A, Larsen BM (2004) Greenhouse gas emissions in Norway: do carbon taxes work? Energy Policy 32:493–505

Commins N, Lyons S, Schiffbauer M, Tol RSJ (2011) Climate policy and corporate behaviour. Energy J 32(4):51–68

Costantini V, Mazzanti M (2012) On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports. Res Policy 41:132–153

Darnall NG, Jolley J, Ytterhus B (2007) Understanding the relationship between a facility's environmental and financial performance. In: Johnstone N (ed) Corporate behavior and environmental policy. Edward Elgar/OECD. http://www.oecdbookshop.org/display.asp?K=5L4THQBS3NTD&LANG=EN

Davis LW, Kilian L (2011) Estimating the effect of a gasoline tax on carbon emissions. J Appl Econom 26(7):1187–1214

De Melo J, Mathys NA (2010) Trade and climate change: the challenges ahead. CEPR Discussion Papers 8032

Di Maria C, Lange I, Van der Werf (2012) Should we be worried about the Green Paradox? Announcement effects of the acid rain program. European Economic Review, Available online 18 April 2013

Di Maria C, Van der Werf E (2010) Carbon leakage revisited: unilateral climate policy with directed technical change. Environ Resour Econ 39:55–74

EEA (2011a) Environmental tax reform in Europe: implications for income distribution. EEA Technical Report 16

EEA (2011b) Environmental tax reform in Europe: opportunities for eco-innovation. EEA Technical Report 17

Ekins P (1996) How large a carbon tax is justified by the secondary benefits of CO_2 abatement? Resour Energy Econ 18:161–187

Enevoldsen MK et al (2007) Decoupling of industrial energy consumption and CO_2-emissions in energy intensive industries in Scandinavia. Energy Econ 29:665–692

EU Climate Change Expert Group (2008) The 2°C target. Information reference document

Fischer C, Salant SW (2012) Alternative climate policies and intertemporal emissions leakage: quantifying the Green Paradox. Resources for the Future Discussion Paper No. 12–16

Gerlagh R (2011) Too much oil. CESifo Economic Studies 57(1):79–102

Ghalwash T (2007) Energy taxes as a signaling device: an empirical analysis of consumer preferences. Energy Policy 35(1):29–38

Godal O, Holtsmark B (2001) Greenhouse gas taxation and the distribution of costs and benefits: the case of Norway. Energy Policy 29:653–662

Goeschl T, Perino G (2012) Instrument choice and motivation: evidence from a climate change experiment. Environ Resour Econ 52:195–212

Golombek R, Hoel M (2004) Unilateral emission reductions and cross-country technology spillover. B E J Econ Anal Policy 3(2):3

Graham DJ, Glaister S (2002) The demand for automobile fuel. A survey of elasticities. J Transp Econ Policy 36(1):1–25

Groosman B, Muller N, O'Neilly-Toy E (2011) The ancillary benefits from climate policy in the United States. Environ Resour Econ 50:586–603

Habermacher F, Kirchgässner G (2011) Climate effects of carbon taxes, taking into account possible other future climate measures. CESifo Working Paper Series 3404

Hoel M (2010) Climate change and carbon tax expectations. CESifo Working Paper Series 2966

Holland SP (2011) Spillovers from climate policy to other pollutants. In: NBER (ed) The design and implementation of U.S. climate policy. http://press.uchicago.edu/ucp/books/book/chicago/D/bo13270829.html

IPCC (2007) Climate change 2007: synthesis report. Contribution of working groups I, II, III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

Jaffe AB, Newell RG, Stavins RN (2005) A tale of two market failures: technology and environmental policy. Ecol Econ 54:164–174

Jaffe AB, Palmer K (1997) Environmental regulation and innovation: a panel data study. Rev Econ Stat 79:610–619

Jaffe AB, Stavins RN (1994) Energy-efficiency investments and public policy. Energy J 15:43–65

Johnstone N, Labonne J (2006) Environmental policy, management and research and development. In: Elmskov J (ed) OECD economic studies 46:169–203

Krysiak FC (2011) Environmental regulation, technological diversity, and the dynamics of technological change. J Econ Dyn Control 35:528–544
Lanjouw JO, Mody A (1996) Innovation and the international diffusion of environmentally responsive technology. Res Policy 25:549–571
Lanoie P, Laurent-Lucchetti J, Johnstone N, Ambec S (2011) Environmental policy, innovation and performance: new insights on the porter hypothesis. J Econ Manag Strat 20(3):803–842
Li S, Linn J, Muehlegger E (2012) Gasoline taxes and consumer behavior. Working Paper Series rwp12-006, Harvard University, John F. Kennedy School of Government
Lin B, Li X (2011) The effect of carbon tax on per capita CO_2 emissions. Energy Policy 39:5137–5146
Mizobuchi K (2008) An empirical study on the rebound effect considering capital costs. Energy Econ 30:2486–2516
Nemet GF, Holloway T, Meier P (2010) Implications of incorporating air-quality co-benefits into climate change policymaking. Environ Res Lett 5(1):014007
Newell RG, Jaffe AB, Stavins RN (1999) The induced innovation hypothesis and energy-saving technological change. Q J Econ 114:941–975
Noailly J (2012) Improving the energy efficiency of buildings: the impact of environmental policy on technological innovation. Energy Econ 34(2):795–806
Nordhaus WD (2010) Carbon taxes to move toward fiscal sustainability. The Economists' Voice 7(3), Berkeley Electronic Press
OECD (2002) Ancillary benefits and costs of GHG mitigation: policy conclusions. Working Party on Global and Structural Policies 13
OECD (2009) Co-benefits of climate change mitigation policies: literature review and new results. OECD Economic Department Working Paper 34
Patuelli R, Nijkamp P, Pels E (2005) Environmental tax reform and the double dividend: a meta-analytical performance assessment. Ecol Econ 55:564–583
Pittel K, Rübbelke DTG (2008) Climate policy and ancillary benefits: a survey and integration into modelling of international negotiations on climate change. Ecol Econ 68:210–220
Pizer WA (2002) Combining price and quantity controls to mitigate global climate change. J Public Econ 85:409–434
Popp D (2002) Induced innovation and energy prices. Am Econ Rev 92(1):160–180
Popp D (2006) International innovation and diffusion of air pollution control technologies: the effect of NOx and SO2 regulation in the US, Japan and Germany. J Environ Econ Manag 51:46–71
Porter ME (1991) America's green strategy. Sci Am 264:168
Porter ME, van der Linde C (1995) Toward a new conception of the environment-competitiveness relationship. J Econ Perspect, American Economic Association 9:97–118
Scott KR (2012) Rational habits in gasoline demand. Energy Econ 34(5):1713–1723
Sinclair PJN (1992) High does nothing and rising is worse: carbon taxes should keep declining to cut harmful emissions. Manch Sch Econ Soc Stud 60:41–52
Sinn H-W (2008) Public policies against global warming: a supply side approach. Int Tax Public Finance 15:360–394
Speck S, Andersen MS, Nielsen HO, Ryelund A, Smith C (2006) The use of economic instruments in Nordic and Baltic Environmental Policy 2001–2005. Nordic Council of Ministers Report
Spinesi L (2012) Global warming and endogenous technological change: revisiting the green paradox. Environ Resour Econ 51:545–559
Sterner T (2007) Fuel taxes: an important instrument for climate policy. Energy Policy 35:3194–3202
Thalmann P (2012) Global environmental taxes. In: Milne JE, Andersen MS (eds) Handbook of research on environmental taxation. Edward Elgar, pp 456–476
UNEP (2011) Bridging the emissions gap. UNEP Synthesis Report. http://www.e-elgar.com/bookentry_main.lasso?id=13862
Weitzman ML (1974) Prices vs. quantities. Rev Econ Stud 41:50–65
Zhang Z, Baranzini A (2004) What do we know about carbon taxes? An inquiry into their impacts on competitiveness and distribution of income. Energy Policy 32:507–518

Annex 2

Centre for Climate Change Economics and Policy

An ESRC Research Centre

Grantham Research Institute on Climate Change and the Environment

Seven reasons to use carbon pricing in climate policy

Andrea Baranzini, Jeroen van den Bergh, Stefano Carattini, Richard Howarth, Emilio Padilla and Jordi Roca

February 2016

Centre for Climate Change Economics and Policy Working Paper No. 253

Grantham Research Institute on Climate Change and the Environment

Working Paper No. 224

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

The Grantham Foundation for the Protection of the Environment

University of Leeds

LSE The London School of Economics and Political Science

The Centre for Climate Change Economics and Policy (CCCEP) was established by the University of Leeds and the London School of Economics and Political Science in 2008 to advance public and private action on climate change through innovative, rigorous research. The Centre is funded by the UK Economic and Social Research Council. Its second phase started in 2013 and there are five integrated research themes:

1. Understanding green growth and climate-compatible development
2. Advancing climate finance and investment
3. Evaluating the performance of climate policies
4. Managing climate risks and uncertainties and strengthening climate services
5. Enabling rapid transitions in mitigation and adaptation

More information about the Centre for Climate Change Economics and Policy can be found at: http://www.cccep.ac.uk.

The Grantham Research Institute on Climate Change and the Environment was established by the London School of Economics and Political Science in 2008 to bring together international expertise on economics, finance, geography, the environment, international development and political economy to create a world-leading centre for policy-relevant research and training. The Institute is funded by the Grantham Foundation for the Protection of the Environment and the Global Green Growth Institute. It has nine research programmes:

1. Adaptation and development
2. Carbon trading and finance
3. Ecosystems, resources and the natural environment
4. Energy, technology and trade
5. Future generations and social justice
6. Growth and the economy
7. International environmental negotiations
8. Modelling and decision making
9. Private sector adaptation, risk and insurance

More information about the Grantham Research Institute on Climate Change and the Environment can be found at: http://www.lse.ac.uk/grantham.

Seven Reasons to Use Carbon Pricing in Climate Policy

Andrea Baranzini[1], Jeroen van den Bergh[2,3,4], Stefano Carattini[1,5],

Richard Howarth[6], Emilio Padilla[7], Jordi Roca[8]

[1] Haute Ecole de Gestion Genève, University of Applied Sciences Western Switzerland (HES-SO)
[2] Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona
[3] ICREA, Barcelona
[4] Institute of Environmental Studies & Faculty of Economics and Business Administration, VU University Amsterdam
[5] Grantham Research Institute on climate change and the environment and ESRC Centre for Climate Change Economics and Policy, London School of Economics and Political Science
[6] Environmental Studies Program, Dartmouth College
[7] Department of Applied Economics, Universitat Autónoma de Barcelona
[8] Faculty of Economics and Business, University of Barcelona

Abstract

The idea of a global carbon price has been a recurrent theme in debates on international climate policy. Discarded at the Conference of Parties (COP) of Copenhagen in 2009, it remained part of deliberations for a climate agreement in subsequent years. Unfortunately, there is still much misunderstanding about the reasons for implementing a global carbon price. As a result, ideological and political resistance against it prospers. Here we present the main arguments in favor of a carbon price to stimulate a fair and well-informed discussion about climate policy instruments. This includes arguments that have received surprisingly little attention so far. It is stressed that a main reason to use carbon pricing is environmental effectiveness, so not only economic efficiency (including the special case of cost-effectiveness). In addition, we provide ideas on how to implement a uniform global carbon price, whether using a carbon tax or emissions trading.

Keywords: climate policy; carbon pricing; carbon tax; emissions trading

1. Introduction

In the aftermath of COP21 in Paris, countries will have to turn pledges into effective policies, to guarantee that their promises about reduction of greenhouse gas emissions are realized. It is easy to underestimate this challenge. We argue that ambitious targets can only be met by using the instrument of carbon pricing, with the ultimate aim of a uniform global carbon price. All alternative options are likely to lead to insufficient, ineffective and very costly abatement activities, thus undercutting the pledge and review system, as well as jeopardizing the potential for more ambitious targets in the future. Our society is at a turning point. Imprudent policy design could have extremely far reaching consequences, not least because of the real chance of dangerous climate change.

However, many observers, notably social scientists, are critical of carbon pricing, even though often without being well informed about its precise impacts and benefits. Here we argue that the main reason for it is not only efficiency or cost-effectiveness, but environmental effectiveness. We provide many reasons, which have been largely overlooked in critical writings on carbon pricing.

2. Characteristics of climate change and implications for policy instruments

Climate change possesses several characteristics that must be accounted for in the formulation of climate policies to guarantee their effectiveness. Sources of anthropogenic emissions are diverse and cover all economic sectors. Emissions arise from both production and consumption, including resource extraction and waste management activities. Hence, abatement costs are very heterogeneous. In addition, greenhouse gas (GHG) emissions accumulate in the atmosphere with residence times stretching from centuries to millennia. Therefore, abatement incentives should be dynamic, i.e. responsive to economic and technological change, and last through time. Moreover, the location of GHG emissions does not have an impact on climate change. As a result, the distribution of GHG abatement efforts can be uneven across space. Another feature of climate change is that there is no simple set of unproblematic end-of-pipe solutions – witness the debate about carbon capture. It follows that it is necessary to abate GHG emissions through a wide range of options, including changes in behavior (e.g. using less energy), structural change in the composition of the economy (dirty versus cleaner sectors and products, and different input mixes in production), more energy-

efficient technologies, and low-carbon (notably renewable) energy production. Finally, particularly challenging for international negotiations is that abatement activities are costly and constitute global public goods; that is, others can benefit from them without undertaking any effort. It is thus necessary to coordinate actions to avoid free-riding behavior and international carbon leakage. Therefore, a worldwide policy is needed to avoid unwanted transboundary displacement of emissions and to ensure fair economic competition between countries.

We argue that carbon pricing supported by a climate agreement is able to address these characteristics of climate change. This becomes clear by considering seven unique advantages of it, as explained hereafter.

3. Seven arguments in favor of international carbon pricing

Carbon pricing affects carbon emissions by penalizing energy sources in proportion to their carbon content. It is easily applicable to emissions coming from energy use, but can be extended to emissions arising from land use changes and other sources. The following are the most important arguments in favor of carbon pricing:

1. In accordance with the Polluter Pays Principle, carbon pricing changes relative prices. As a consequence, when making decisions that cause carbon emissions, firms and consumers will not just take into account their private costs and benefits, but will automatically account, without necessarily being aware of it, for the social costs due to (direct and indirect) carbon emissions generated in every phase of the product life cycle from resource to waste. The entire economy can then become less carbon-intensive, since all consumers and producers will adjust their decisions to prices corrected for the climate externality. The carbon price should, though, be high enough to induce the required adjustments leading to the emissions abatement objective.
2. Compared to other types of instruments, carbon pricing can address the vast heterogeneity of greenhouse gas emitters, thus helping to minimize the cost of pollution control. Heterogeneity might result from firms having different production (and thus emitting) technologies, sizes, organizations, etc., which translates into distinct marginal pollution abatement costs. In theory – assuming perfect information and substantive rationality – all polluters should choose that level of

emissions abatement for which the associated marginal cost equals the carbon price. With a unique carbon price, the marginal abatement costs would then be identical among all polluters, which implies that a particular abatement goal will be met at the least global cost. No other instrument than pricing is able to realize this goal. However, since polluters are not always perfectly aware of relevant abatement technologies and associated costs, one may expect that the actual global cost will not reach the lowest level. Nevertheless, empirical research suggests that reliance on non-price policy instruments can lead to considerably higher abatement costs in the absence of price incentives (Pizer 2002; Fischer and Newell 2008). The reason is that such instruments are less effective in covering diverse sources of emissions (e.g. technical standards cannot be applied subtly to all millions of technologies and products in the world). Instead, a carbon price is a systems-approach that spans over all sources of emissions.

3. Carbon pricing contributes to dynamic efficiency. That is, through time it stimulates research and development, innovation and adoption of new technologies emitting less carbon. By increasing the cost of carbon-emitting technologies and activities, carbon pricing provides a financial incentive for consumers and producers to invest in technologies reducing emissions. Empirical evidence suggests indeed a positive relationship between higher energy prices and the development of (green) innovation technologies (Ambec et al. 2013). Compared to emission or technology-based standards, carbon pricing can provide a higher economic incentive (benefit) for adoption of, and R&D on, improved abatement technologies (Jaffe and Stavins 1995). Carbon pricing is thus an important element of a policy package aimed at redirecting technical change towards the cleaner goods and ways of production (Acemoglu et al. 2012; Aghion et al. 2012). Indeed, without ecologically corrected prices one cannot expect innovation to be well oriented. This is underappreciated in many discussions about technological change and climate change, where pricing is downplayed as if innovation/diffusion subsidies and other innovation policies (information provision, stimulating cooperation between innovators) were sufficient. But carbon pricing and technology policy are largely complementary mechanisms and should thus both be part of a climate policy package.
4. Carbon pricing is the best instrument to control energy and carbon rebound in an effective way.

Technological advances and improvements in energy efficiency tend to lead to a direct reduction in energy consumption. However, given the improved efficiency, the energy services – for instance, travelling by car – become cheaper. As a result, there is a general empirical consensus that people consume more energy than if energy efficiency improvements would not imply any change in behavior (Sorrell 2007). We argue that opportunities for such rebound effect would be limited if carbon pricing is in place (van den Bergh 2011). For example, it will discourage the more intense use of a more efficient and – without a carbon price – cheaper technology (e.g., a car with more fuel-efficient engine). In addition, it will discourage any money savings due to energy conservation to be spent on energy-intensive goods and services, as these will have a higher price due to carbon pricing. Empirical evidence suggests indeed that this so-called "re-spending rebound" is non-negligible (Antal and van den Bergh 2014). Carbon pricing would, moreover, not only reduce rebound with respect to the *laissez faire*, but also with respect to other policy options. While standards tend to control energy use and emissions only for a subset of technologies and associated services, carbon pricing can be regarded as a systems approach that discourages rebound consistently across all carbon-intensive goods and technologies (van den Bergh 2015). Finally, pricing will also assure that consumers can make a trade-off between the benefits and total (including environmental) costs of rebound resulting from their decisions. This assures that rebound associated with higher benefits than environmental damages will persist under carbon pricing. In other words, such rebound effects will not be eliminated by carbon pricing. Carbon pricing thus comes out as the best policy to deal with rebound, in terms of effective control and welfare effects.

5. An international carbon price covering all countries and sectors would ensure that there are no leakages – i.e. indirect unintended and unwanted production, consumption, innovation and diffusion effects that create more carbon emissions elsewhere. With consistently higher relative prices for all carbon-intensive products worldwide, there are no escape routes: all economic agents and thus countries will be stimulated to search for cheaper and thus less carbon-intensive alternatives. As suggested by Nordhaus (2015), if some countries would opt for not enforcing such a policy, free riding could be avoided – or reduced – by trade sanctions. Nordhaus proposes strong

trade sanctions unrelated with the carbon content of trade. However, sanctions could also take the form of border carbon taxes on imports of non-complying countries, which, even though insufficient to ensure the incorporation of all countries in international climate policy, would contribute to address the problems of competiveness associated to carbon taxes.

6. Carbon pricing allows for flexibility and autonomy of choice, as emitters can freely change their behavior to reduce their costs. This means decentralization of policy, with associated low information needs. In addition, carbon pricing – instead of, e.g., eco-labeling – means that no separate life-cycle analysis is needed to account for all the carbon emissions of products and services over their life-cycle. Instead, firms will integrate carbon prices in existing cost-accounting systems of their products and services. This has the additional advantage that transaction costs are limited.
7. Even if one is environmentally conscious, it is virtually impossible to know which goods to buy and in what amounts to achieve one's environmental goals. Moreover, even though many people would like to contribute at a personal cost to a more responsible use of resources, such cooperative behavior may depend on the perception that others will or will not do the same (Ostrom 2009). The fact that an individual action alone has a negligible impact tends indeed to discourage people to undertake these voluntary actions. Moreover, many consumers are not particularly environmentally conscious in their purchase behavior, being sensitive to personally salient concerns, notably financial considerations, when making purchasing decisions. An effective climate policy should reach out to this majority: carbon pricing regulation will be capable of doing this as it naturally intervenes in the core element, namely pricing, of markets. It does so without assuming that people will act altruistically, showing voluntary environmentally benign behavior, or can handle much information about products, as in the form of eco-labels.

Even if a global carbon price existed, other climate change policies will still be necessary. In particular, given the public good characteristics and lock-in problems of technological innovation and R&D activities, subsides or direct investment should be encouraged. Moreover, since in practice carbon pricing can hardly cover all GHG emissions, other policy instrument should be implemented.

Finally, given informational failures and bounded rationality, carbon pricing can always be supplemented with mechanisms that aid households and businesses respond effectively to market signals and incentives (see Sanstad and Howarth 1994). Carbon pricing is thus not enough to confront all the challenges of climate change, which is not an argument against pricing and its unique and desirable properties, but a reason to complement it with additional policies. In this respect, we agree with (Bowen 2011, p. 2), who says "Other policies are needed, too, particularly to promote innovation and appropriate infrastructure investment, but cannot be relied upon by themselves to bring about the necessary reductions in emissions. Carbon pricing is crucial".

A not unusual resistance against carbon pricing is motivated by the argument that it will be inequitable, i.e. have adverse, regressive distributional effects in terms of income or consumers' purchasing power. But this is a too generalized statement. Distributional effects strongly depend on the design of carbon pricing and the broader set of policies of which it is part. Paradoxically, carbon pricing, provides an excellent instrument to address undesirable distributional consequences – notably if taking the form of carbon taxation, but also of emissions trading, if initial permits are auctioned or sold. The reason is that it will generate public revenues that can in turn be used to compensate low-income households, e.g. through tax reductions for low incomes or energy poor households, or lower VAT rates for products serving basic needs (Harrison 2013; Bowen 2015; Thomas and Flues 2015). However, progressive effects can also be obtained by lump sum redistribution, which represents the simplest and administratively less burdensome way of recycling revenues from carbon pricing (Baranzini, Goldemberg, and Speck 2000; Metcalf 2009).

This critique of carbon pricing further presumes that the comparable scenario is the status quo, and neglects the distributional impacts of climate change or of other instruments of climate policy. For example, technical standards will not necessarily provide better guarantees for an equitable distribution of emissions reductions and associated monetary and welfare costs. In particular, they will also raise costs and thus prices, but not generate extra public revenues that could be used to lessen perceived unfair distributive impacts.

In a review of arguments and empirical studies, Fullerton (2011) warns that assessing distributional effects of environmental policy (any, also other instruments than pricing) is a difficult

task, at it involves six elements: (1) higher prices of carbon-intensive products, (2) changes in relative returns to factors like labor, capital, and resources, (3) allocation of scarcity rents from a restricted number of permits, (4) distribution of the benefits from improvements in environmental quality, (5) temporary effects during the transition, and (6) capitalization of all those effects into prices of property values (land, buildings, houses). A good assessment should account for all of them.

4. Practical implementation of international carbon pricing

Two main instruments can achieve a unique worldwide carbon price: a global carbon tax and a global emissions trading system. While a carbon tax sets the carbon price directly through an administrative decision, an emissions trading system sets a cap on emissions and allocates the emission allowances between emitters, who can then trade them resulting in a carbon price. While they have different advantages and drawbacks, both instruments share the general favorable properties mentioned above. There is not an unambiguously better alternative, which explains why each option has its own advocates.

The most important difference between emission trading and carbon taxes concerns control of quantities versus price (Weitzman 1974). Emissions trading systems, by setting a cap, can guarantee the achievement of a given environmental objective. However, the price is uncertain. In contrast, in the case of carbon taxes, the price is known, but the level of emissions is uncertain. Emissions trading systems have been criticized for their volatility, which may be an important handicap for long-term investments, as these depend not only on current prices, but also on expectations about future prices. However, carbon prices in emissions trading systems do not necessarily have to be extremely volatile. Price floors and ceilings (so-called “safety valves”) have been proposed to address the issue of volatility; one way to assure a minimum price takes the form of a mix system, namely a permanent tax and a permits market (Wood and Jotzo 2011).

4.1. Implementing a carbon price through a tax

There are two possible international carbon tax designs, both of which require an international climate agreement. One is a global carbon tax, the revenues of which would be collected centrally, e.g. through

the UNFCCC Secretariat, and subsequently redistributed among countries, e.g. in relation to their demographic weight. Despite its political difficulty, this alternative would clearly be the preferred option, as it would imply a single worldwide carbon price. It would have positive international redistributive effects given the positive correlation between per capita GHG emissions and per capita income. A part of the revenues might be allocated to the provision of green funds financing environmental projects or adaptation measures in poorer countries. Despite economists have long advocated to fund only the socially most profitable investments, public acceptability studies show that using revenues from carbon taxes to finance environmentally beneficial projects can increase their social and political acceptability (Drews and van den Bergh, 2015).

The second alternative would be a tax raised by each country, while aiming at a single global carbon price through harmonized carbon taxes. By agreeing about this harmonized tax, countries would not be tempted to deviate from it for competitiveness or political-ideological reasons, which have been shown to substantially hamper the effectiveness of early efforts to implement carbon taxes (Baranzini and Carattini 2014). A drawback of harmonized taxes is that national governments would be less interested in reducing emissions with complementary policies, because any reduction of emissions would reduce fiscal revenues in contrast with a global tax (Hoel 1992). Thus, this second option should be judged as less attractive in environmental terms, but more viable politically.

4.2. Implementing a carbon price through emissions trading

An international emissions trading system could also take different forms. A truly global market would cover all individual emitters, giving rise to a single carbon price worldwide. This would assure cost-effectiveness of mitigation at a global level. However, creating such a global system of emission trading is very challenging in both political and institutional terms. Alternatively, an international treaty would fix a global emissions cap and then distribute allowances between countries, which could trade them fixing the global carbon price. In this case, countries could choose whether and how to introduce carbon pricing domestically as it would be desirable. However, similarly to carbon taxes, it could be easier to start with different emissions trading systems covering certain countries and regions (like the EU) and sectors, and integrate these globally in a subsequent stage. In the long run, this could

lead to the coverage of all countries and sectors. Indeed, similarly to carbon taxes, various cap-and-trade systems are and have been developed in North America, Europe and Asia, forming a fertile basis for integration at a larger, global scale.

Setting rules of allocation of allowances among countries and emitters in each country is a major hurdle, since they reflect implicit ethical and political choices. The grandfathering approach used in many programs favors large emitters and penalize those who made mitigation efforts before the policy implementation. As a result, there is now broader support for initializing systems through auctioning permits, also as this would contribute to efficiency. However, while this is feasible for firms, as the EU ETS program has shown, its application to countries is less evident. As for carbon taxes, distributional concern would play in favor of either a redistribution of revenues from permit auctions based on the demographic weights of countries or the direct allocation of allowances on per capita basis. Hence, both could be progressive in terms of inter-country distribution and so address one of the criticisms to global carbon markets in particular and global carbon pricing in general.

5. Conclusions

We have presented seven reasons for using carbon pricing in climate policy:

1. It changes relative prices to reflect all direct and indirect CO_2 emissions of products and services so that firms and consumers will automatically internalize the costs of global warming.
2. It minimizes the overall cost of pollution control as it accounts for differences (heterogeneity) between polluters in terms of abatement opportunities and costs.
3. It contributes to dynamic efficiency, because it provides continuous incentives for adoption and innovation of new technologies that emit less carbon dioxide.
4. It is the best instrument to control energy and carbon rebound in an effective way and avoiding undesirable welfare effects.
5. If it were to cover all countries and sectors, it would ensure that there are no leakages through international relocation of dirty industries and shifts in foreign trade patterns that merely replace carbon emissions from one countries to another.

6. It implies decentralization of policy, with associated low information needs for regulators.
7. It relies on the empirical fact that when making purchase decisions, most consumers with regard to purchasing most products and services are more influenced by prices than by environmental concerns.

As a result, carbon pricing will be a very effective instrument, particularly because of reasons 1, 3, 4, 5, and 7. Many countries already have implemented policies to stimulate climate change mitigation, including carbon taxes and emissions trading schemes (World Bank 2014). However, these policies have been relatively ineffective as the levels of the policy instruments are often weak in the absence of a serious international climate agreement, to avoid negative implications for the respective countries' competitive position as well as carbon leakage (point 5).

Emissions pledges have been at the center of climate negotiations preparing for COP21 in Paris. We believe that negotiating around a single price will become easier as more countries get involved in carbon pricing and an increasing number of people become well informed about the unique advantages of carbon pricing. In view of these, we should remove ideological barriers against such a critical element of an effective climate policy package. We hope that the seven arguments in favor of carbon pricing presented here can convince readers that such an approach to climate policy deserves serious attention and debate. Anyone who is critical of carbon pricing needs to address these seven pro-arguments, as well the arguments (at the end of Section 3) on how carbon pricing can be designed to have desirable equity effects. Moreover, those critical of carbon pricing should be able to present an alternative that is similarly effective in reducing greenhouse gas emissions. As we have argued, all alternative options are likely to result in considerably less effective, even though well-intended, ways of regulating emissions and thus are likely to be unable to avoid dangerous climate change.

Acknowledgements

Andrea Baranzini and Stefano Carattini acknowledge financial support from the Swiss Federal Office of Energy. Emilio Padilla and Jordi Roca acknowledge support from the projects ECO2015-67524-R (Ministerio de Economía y Competitividad) and 2014SGR950 (Direcció General de Recerca).

References

Acemoglu, Daron, Philippe Aghion, Leonardo Bursztyn, and David Hemous. 2012. "The Environment and Directed Technical Change." *American Economic Review* 102 (1): 131–66.

Aghion, Philippe, Antoine Dechezleprêtre, David Hemous, Ralf Martin, and John Van Reenen. 2012. "Carbon Taxes, Path Dependency and Directed Technical Change: Evidence from the Auto Industry." *NBER Working Papers*.

Ambec, Stefan, Mark A. Cohen, Stewart Elgie, and Paul Lanoie. 2013. "The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness?" *Review of Environmental Economics and Policy* 7 (1): 2–22.

Antal, Miklós, and Jeroen C.J.M. van den Bergh. 2014. "Re-Spending Rebound: A Macro-Level Assessment for OECD Countries and Emerging Economies." *Energy Policy* 68: 585–90.

Baranzini, Andrea, and Stefano Carattini. 2014. "Taxation of Emissions of Greenhouse Gases." In *Global Environmental Change*, edited by Bill Freedman, 543–60. Handbook of Global Environmental Pollution 1. Springer Netherlands.

Baranzini, Andrea, Jose Goldemberg, and Stefan Speck. 2000. "A Future for Carbon Taxes." *Ecological Economics* 32 (3): 395–412.

Bowen, Alex. 2011. "The Case for Carbon Pricing." *Policy Brief, Grantham Research*.

———. 2015. "Carbon Pricing: How Best to Use the Revenue?"

Drews, Stefan, and Jeroen C. J. M. van den Bergh. 2015. "What Explains Public Support for Climate Policies? A Review of Empirical and Experimental Studies." *Climate Policy*

Fischer, Carolyn, and Richard G. Newell. 2008. "Environmental and Technology Policies for Climate Mitigation." *Journal of Environmental Economics and Management* 55 (2): 142–62.

Fullerton, Don. 2011. "Six Distributional Effects of Environmental Policy." Working Paper 16703. National Bureau of Economic Research.

Harrison, Kathryn. 2013. "The Political Economy of British Columbia's Carbon Tax." OECD Environment Working Papers. Paris: Organisation for Economic Co-operation and Development.

Hoel, Michael. 1992. "Carbon Taxes : An International Tax or Harmonized Domestic Taxes?" *European Economic Review* 36 (2-3): 400–406.

Jaffe, Adam B., and Robert N. Stavins. 1995. "Dynamic Incentives of Environmental Regulations: The Effects of Alternative Policy Instruments on Technology Diffusion." *Journal of Environmental Economics and Management* 29 (3).

Metcalf, Gilbert E. 2009. "Designing a Carbon Tax to Reduce U.S. Greenhouse Gas Emissions." *Review of Environmental Economics and Policy* 3 (1): 63–83.

Nordhaus, William. 2015. "Climate Clubs: Overcoming Free-Riding in International Climate Policy." *American Economic Review* 105 (4): 1339–70.

Ostrom, Elinor. 2009. "A Polycentric Approach for Coping with Climate Change." Policy Research Working Paper Series. The World Bank.

Pizer, William A. 2002. "Combining Price and Quantity Controls to Mitigate Global Climate Change." *Journal of Public Economics* 85 (3): 409–34.

Sanstad, Alan H., and Richard B. Howarth. 1994. "'Normal' Markets, Market Imperfections and Energy Efficiency." *Energy Policy* 22 (10): 811–18.

Sorrell, Steven. 2007. "The Rebound Effect: An Assessment of the Evidence for Economy-Wide Energy Savings from Improved Energy Efficiency." Project Report. UK Energy Research Centre.

Thomas, Alastair, and Florens Flues. 2015. "The Distributional Effects of Energy Taxes." OECD Taxation Working Papers 23.

van den Bergh, Jeroen C. J. M. 2011. "Energy Conservation More Effective With Rebound Policy." *Environmental and Resource Economics* 48 (1): 43–58.

———. 2015. "Climate Summit: Pricing Would Limit Carbon Rebound." *Nature* 526 (7572): 195–195.

Weitzman, Martin L. 1974. "Prices vs. Quantities." *Review of Economic Studies* 41 (4): 477–91.

Wood, Peter John, and Frank Jotzo. 2011. "Price Floors for Emissions Trading." *Energy Policy* 39 (3): 1746–53.

World Bank. 2014. "State and Trends of Carbon Pricing 2014." World Bank Group.

Annex 3

h e g

Haute école de gestion de Genève
CRAG - Centre de Recherche Appliquée en Gestion
Cahier de Recherche

Economic Prescriptions and Public Responses to Climate Policy

Andrea Baranzini, Metin Caliskan and Stefano Carattini

Cahier : N° HES-SO/HEG-GE/C-14/3/1--CH

2014

Hes·so GENÈVE
Haute Ecole Spécialisée de Suisse occidentale

Economic Prescriptions and Public Responses to Climate Policy

Andrea Baranzini[*], **Metin Caliskan**[*] **and Stefano Carattini**[*†‡]

Cahier de recherche

November 2014

Abstract

Public acceptability is one of the main barriers to the implementation of carbon taxes. Qualitative evidence based on a sample of individuals interviewed in Geneva, Switzerland, shows that the general public would not tackle climate change as economists suggest. The gap concerns not only the choice of climate policy's instruments (i.e. pull versus push measures), but also its specific design in the case of carbon taxes. In this respect, the gap is driven by a diffused perception of environmental ineffectiveness of carbon taxes, which goes hand in hand with distrust in the government and a strong demand for earmarking carbon tax revenues for environmental purposes. Our empirical findings are consistent with the recent literature on the public's preferences on environmental policy design and provide new evidence for the need to reconsider the conventional approach to economic instruments and environmental tax reforms. Reducing resistance to the implementation of Pigouvian taxes cannot abstract from providing effective responses to the concerns emphasized by the general public.

Policy relevance

Policy design is key to improve acceptability of climate policy in general and of economic instruments in particular. Given the current understanding and perception of carbon taxes by the general public, there is a substantial trade-off between efficiency- and acceptability-enhancing use of revenues from carbon taxes. Earmarking revenues for environmental purposes clearly reduces perceived complexity and increases acceptability. The paper addresses this trade-off and, drawing on the Swiss experience, discusses how making financial and environmental benefits salient may improve the acceptability of carbon taxes. It also considers the implementation of climate policies directed towards voluntary efforts, which enjoy larger support by the general public.

Keywords

Climate policy; Carbon tax; Social responses; Public acceptability

[*]Haute école de gestion de Genève, HES-SO // University of Applied Sciences Western Switzerland

[†]Corresponding author: stefano.carattini@hesge.ch

[‡]Faculty of Business and Economics, University of Barcelona

1 Introduction

Climate change is one of the most pressing issues of this century. International negotiations aim at stabilizing emissions at a level preventing severe changes in the climate system. However, they have generally failed to provide consistent and ambitious agreements. Unilateral initiatives have emerged in most developed countries, but the choice of instruments can be questioned from an economic perspective (cf. IPCC 2014; World Bank 2014). Following the IPCC (2014), we classify climate policy instruments in five categories. The first category encompasses the market-based approach, i.e. economic instruments such as taxes and emissions trading systems. In a pure theoretical world, carbon pricing would represent the first best policy (cf. Baumol and Oates, 1971). The second category refers to regulatory approaches (i.e. standards), which are still much diffused instruments of environmental policy, even though theoretically inferior to economic instruments. The remaining categories are represented by information policy (e.g. labels), public provision of goods and services (e.g. public transportation) and voluntary actions and agreements.

The evidence suggests that unilateral initiatives have often lacked to implement powerful instruments able to dramatically curb emissions, such as carbon taxes. When implemented, large exemptions hampered their effectiveness (Lin and Li, 2011; Baranzini and Carattini, 2014). In many other instances, governments preferred second-best policies such as subsidies for renewables and energy-saving measures, eventually leading to relatively high implicit carbon prices (see e.g. OECD 2013; Marcantonini and Ellerman 2014). The explanations of this pattern rely on the political economy of climate change mitigation.

We address this issue from a perspective of public acceptability. We follow a qualitative approach based on face-to-face interviews and ask to members of the general public what measures are necessary to reduce energy consumption and greenhouse gas emissions, what is the role of the public sector and the place for carbon taxes as a policy instrument. We carry out our interviews in Geneva, Switzerland. As other European countries, just after the ratification of the Kyoto Protocol, Switzerland attempted to implement an ambitious mitigation strategy relying on energy taxes. However, in 2000 three energy-tax proposals were rejected by the population in a public ballot (cf. Thalmann, 2004). Since then, Switzerland's climate policy, whose cornerstone is the 2001 CO_2 Act, relies mainly on a mix of policy instruments, including regulations, voluntary agreements (cf. Baranzini et al., 2004) and, by 2008, a carbon tax on heating fuels. The 2013 revision of the CO_2 Act increased the CO_2 tax rate and introduced several regulations, e.g. on imported cars. Political-economy aspects played a crucial role in shaping this path.

Our qualitative evidence suggests that the path followed by Switzerland and other similar countries is in line with the social perception of its population. This paper thus complements the recent literature on the public acceptability of mitigation policies (cf. e.g. Thalmann, 2004; Dresner et al., 2006a; Kallbekken and Sælen, 2011; Sælen and Kallbekken, 2011; Cherry et al., 2012; see also our companion paper Carattini and Baranzini, 2014). The remainder of the paper

is as follows: section 2 reviews the methodology, section 3 introduces the qualitative results, section 4 discusses them and draw policy implications, section 5 concludes.

2 Methodology

This qualitative study is based on a pre-tested semi-structured questionnaire with five face-to-face open questions to 38 individuals. The interviews last between 15 and 45 minutes, averaging about 30 minutes. For each general question, we conceive some possible follow-up questions (in parentheses below) to help people to elaborate their thoughts. The questionnaire is given as follows[1] :

1) By what means it is possible to reduce energy consumption?
(For businesses? For households?)

2) How can reductions in energy consumption be encouraged?
(Who would be the target? Has the public sector any role to play?)

3) Carbon taxes are often mentioned as a policy instrument to reduce energy consumption. Do you think that they are a good approach?
(What features would make them more acceptable to you?)

4) How should tax revenues be used?
(Here are three options: funding environmental projects; redistribution to most affected households; tax rebates for households and firms)

The design of the questionnaire relies on a series of classroom discussions and focus groups, organised prior to the qualitative survey. Participants involved were either "standard" undergraduate or part-time employed students. This first step provides a first sense of how big may be the gap between economists and the public on climate policy and contributes to structure the questionnaire. In particular, students tended to ignore the incentive effect of carbon taxes, despite having seen the concepts of price elasticity and externality in introductory microeconomics courses.

As shown by Table A.1, the sample of respondents is relatively heterogeneous. The sample is composed of individuals of all income classes and includes most age categories. Different job profiles are represented and a large majority of respondents are tenants, in line with the Swiss real-estate context. Though, given the small size typical of qualitative studies, there is no pretention of being representative of the underlying population. The interviews were analysed with RQDA software (Huang, 2012), a computer-assisted qualitative data analysis software.

3 Results

The questionnaire starts with a very general question on how to reduce energy consumption (for households and businesses). We observe a certain degree of consensus across individuals, as

[1]We do not discuss here an additional question asking for future energy price expectations, since beyond the scope of this paper (for more details, see Carattini and Baranzini, 2014).

most answers suggest voluntary measures such as energy-saving tips (cf. Table 1). In particular, use of public transportation and electric vehicles, adoption of energy-efficient lightning and appliances, reduced water consumption and preference for local food products are repeatedly mentioned as possible ways to reduce energy consumption. In general, respondents focus on household's activities, often drawing on their everyday experience, and show a marked preference for measures avoiding to waste energy and as such involving very limited costs for the agent (in terms of e.g. money, time, effort; cf. Steg and Vlek, 2009). For instance, several answers refer to overheating:

> "In winter, at home, we could get a sweater and do not walk around barefoot. Decreasing the indoor temperature to 20°C or 19°C is perhaps not a big deal, but that effort made by all would have a positive impact, surely." *[JRC1, male, 26]*

> For heating, he says that we should not adjust the temperature too high "better to wear a sweater than heating up to 22°C." *[KH4, male, 27]*

> "At home, they could turn off the underfloor heating. In winter, we are burning!" *[LRG2, female, 32]*

We observe a similar approach on measures to reduce energy consumption by firms. Reducing printing and switching off lights and computers are recurrent eco-friendly suggestions, as well as promoting environmentally-aware behaviour within the firm. Here are some typical answers:

> She evokes the large corporations that leave all night long all office lights on. She is strongly against this kind of practice. She also thinks that department stores' luminous signboards could be turned off during the night. *[DM2, female, 65]*

> She replies that if companies made an effort with their incredible holiday decorations, it would already be a step forward. *[JRC2, female, 56]*

We emphasize that only in a few cases the public sector is taken into consideration. According to a few respondents, the government could give incentives to households and firms or apply directly some of the aforementioned tips to its own operations. Incentives are suggested under the form of subsidies (e.g. to public transportation) or energy taxes. Altogether, this may suggest that for the large majority of our interviewees the public sector should not take an active role to curb energy consumption in Switzerland. That is, emission abatements should mainly rely on private efforts. Since following our classroom discussions we were expecting this type of outcome, question 2 asks how to encourage energy consumption abatement, introducing explicitly the public sector.

As reported in Table 2, the government has a role to play according to the majority of respondents, but this is confined to awareness-raising and persuasion. This figure is consistent with answers to question 1. Indeed, respondents contend that the responsibility of the public sector is to stimulate voluntary efforts to reduce energy consumption, such as the ones discussed above. Hence, it seems that most respondents would like to see the public sector getting involved in promoting cooperation among individuals so to reduce energy consumption and contribute to climate change mitigation.

Measures	Household	Business	Public sector
Energy-saving tips			
Reduce heatconsumption	15	1	
Reduce air conditioning		2	
Reduce water consumption	12		
Turn off lights	12	10	
Use energy-efficient lighting	6	1	
Use bicycles	4	2	
Use public transports	13	2	
Pool cars	3		
Use hybrid/electric cars	3	1	
Turn off computers	1	7	
Turn off other electrical appliances	10		
Reduce street light intensity			2
Promote eco-friendly measures		6	2
Print less		5	
Sort waste	3	2	
Buy local food	4	1	
Buy A-label appliances	3		
Install efficient isolation	5	3	1
Install solar panels	6	2	
Install video-conference appliances		1	
Market instruments			
Reduce train fares			1
Increase flight prices			1
Introduce carbon taxes			2
Give tax credits conditional to energy efficiency investments			1
Total	100	46	10

Table 1: Number of times energy saving measures are mentioned (question 1)

"It [the government] has to inform the public. For instance, by publishing factsheets or through advertisements." *[SB1, female, 46]*

"Children should be educated to this issue. And more: subsidizing organic farming and keep financing awareness-raising campaigns." *[NB2, male, 23]*

"Raising awareness is important. That is the role of the public sector, there should be an ecological system to be proposed to everybody!" *[LRG1, female, 24]*

"It should raise awareness through awareness-raising campaigns showing the worldwide effects of energy, water, etc. overconsumption." *[TDS1, male, 23]*

Again, a few respondents evoke that the government could implement economic instruments, but subsidies (in particular taking the form of tax rebates) are much more preferred than

Interventions	N
Awareness-raising and suasion	
Promoting energy savings	23
"Green schooling"	4
Promote renewables	3
Create new labels	1
Diffusing smart metering	1
Taxes	
Increasing prices (e.g. electricity, waste)	4
Subsidies	
Giving tax credits to green firms and households	11
Subsidizing public transports for low-income households	4
Subsidizing (very general)	2
Subsidizing efficient appliances	2
Subsidizing local food	1
Subsidizing homeowners to improve energy efficiency	1
Infrastructure	
Developing bikeways	1
Developing recycling facilities	1
No intervention	
No role to play	2

Table 2: Number of times government interventions were mentioned (question 2)

taxes, especially by those that did not consider the public sector in question 1. That is, only a very small minority thinks spontaneously of carbon taxes as a potential mean to tackle energy consumption and emissions. Those answers are to some extent coherent. They show that people are willing to undertake measures to reduce energy consumption either if these do not imply any cost or, if they do, provided that financial compensation (e.g. subsidies) is offered. From a political perspective, answers to this question seem backing up the choice done by many European governments to give priority to subsidies to e.g. energy-efficiency investments and renewable energy. The lack of support for carbon taxes comes as no surprise and analysing its determinants is one of the aims of this study. Question 3 thus explicitly proposes carbon taxes as a policy instrument and asks for the respondent's opinion on it.

We observe an important amount of discussion around this question. We cluster respondent's answers based on the following themes: perceived environmental effectiveness, trust in the government and distributional effects. Concerning perceived effectiveness, an important proportion of respondents raises serious doubts about the tax effectiveness. For them the tax would hardly reduce energy consumption:

> "Taxing more? I do not know. . . [. . .] We are forced to consume, it is not with a tax that this is going to change." *[DM1, male, 30]*

> The respondent claims he never thought that the simple fact of charging someone an additional tax would substantially affect his way of living and consuming. *[TDS2, male, 29]*

> "I only see increased bills [...]. Though, why not, if it could incite the population to reduce energy consumption, but I do not really think so." *[SB1, female, 46]*

The recurrence of the argument about the tax environmental (in-)effectiveness seems pointing to a widespread underestimation of carbon taxes. On top of that, we note that a few individuals claim that with a carbon tax they would face a motivational crowding-out, i.e. the tax would decrease their efforts to reduce energy consumption. Conceptually, this effect can be defined as the consequence of a behavioural reversal that intervenes when agents feel to be treated unfairly with respect to a moral decision between a "good" and a "bad" action. That is, the introduction of an instrument such as a tax would imply that "no behaviour is good enough not to be penalized" (Goeschl and Perino, 2012). With the words of Frey and Jegen (2001), the policy instrument either modifies the agent's preferences or the perception of her duty, her environment or herself.

> "Energy taxes could end up discouraging efforts. [...] A system of sanctions would be fairer." *[SB3, male, 57]*

> She saves energy already and there is no reason to tax current efforts. She would perceive it as unfair and instead of saving more she would do the opposite. This because her previous efforts would not be rewarded. *[TDS3, female, 53]*

> This would generate the opposite outcome since for those already saving energy this would be perceived as totally unfair as they already save energy. Thus, she would stop saving energy. Since be paying, better enjoying then. *[TDS4, female, 23]*

Albeit not referring to a potential crowding-out, another respondent underlines the unfairness (as she perceives it) of carbon taxation:

> Respondent says that it is not normal that the good citizen is not thanked for her efforts. And that she has to pay for bad citizens. A control of bad consumers should be established so to tax them further. *[KH2, female, 29]*

Twelve respondents express a lack of confidence in the government and policymakers. Some explicitly mention distrust, while others raise worries about the use of tax revenues. For some, carbon taxes are only a pretext to raise new fiscal revenues. That is, a Pigouvian tax simply hiding a Ramsey tax. In several cases, respondents state a need for transparency in the use of revenues, which may condition their support to the policy:

> He would like to know exactly what is done with the money. "We need the federal agency in charge of this tax to provide us with all the information and explanations." *[MG2, male, 31]*

> "To accept [...] it would be necessary to know where tax revenues go." *[TDS4, female, 35]*

> Yes, if this tax really contributes to specific projects. "If it is just a pretext to make money, that is no good!" *[LRG4, male, 35]*

> "The government says what you have to do and you do not really know where the money goes [...]. Perhaps the government one day will tax our own exhalation of CO_2 and discourage sports." *[MG1, male, 25]*

Distrust in the government leads some individuals to ask for ex-ante earmarking already at this stage of the discussion:

> She would like to make sure that her money is really going to renewable energy projects. *[DM3, female, 30]*

> "Yes, if the tax contributes to the development of renewable energy. However, we will never be sure..." *[LRG3, female, 30]*

Respondents tend to identify earmarking with the financing of environmental investments and in particular the development of renewable energy. We explore this issue more in detail while analysing question 4.

Distributional issues seem to be a concern for about half of the sample. Some respondents are simply worried about how the tax would hit the poorest households. Others propose possible solutions to overcome the regressive impact of carbon taxes (cf. Baranzini et al., 2000).

> "Those with money will keep consuming. At the end of the day, we always hit those without it." *[DM3, female, 30]*

> "It is important not to penalize the poorest people." *[NB1, male, 80]*

> "The situation is already sufficiently difficult with respect to the current economic crisis. Paying an additional tax seems to me a bad idea, above all in time of crisis." *[SB4, female, 46]*

> "On the one hand, it would force people to get involved, but on the other it would be unfair for people who already face financial problems. However, applying a tax based on the situation of each household would be acceptable." *[NB4, male, 23]*

> "This tax should be proportional to income and consumption." *[MG2, male, 31]*

Question 4 provides respondents with the possibility to define their preferred way of revenue recycling, i.e. how they would use the revenues from this hypothetical carbon tax. Although it is an open question and thus respondents can mention any kind of revenue recycling, we suggest three options:

1) Funding of environmental projects.

2) Redistribution to most affected households.

3) Tax rebates for households and firms.

Some respondents weigh all options and introduce new ones (e.g. development aid, education), but most of our sample focuses directly on the funding of environmental project. For them, there has to be a natural and logical link between the tax purpose and the use of revenues. A few individuals really struggle to conceive how revenues could be used for other purposes than the environment.

> "It seems normal that revenues would be used in the energy domain." *[SB3, male, 57]*

> "It is clear that such tax has to provide funding to ecological projects, first of all because this is the denomination of the tax." *[SC2, male, 30]*

> "Tax revenues should definitely be used for environmental projects." *[TDS4, female, 23]*

> "Tax revenues should be used in the field of energy and the environment in general. It must be a closed circle. The tax has to pursue its target and allow things to improve." *[MG3, male, 60]*

> "It is an energy tax, so its revenues should be used to develop green technologies." *[DM4, female, 34]*

> "The money obtained would be invested in renewable energies and this would allow finding new efficient solutions. It would be getting two birds with a stone!" *[NB3, female, 20]*

The second recycling option targets the tax's distributional effects by redistributing income to the most disadvantaged households. Its reception is relatively lukewarm. Only few people particularly concerned by distributional effects believe that social cushioning is necessary:

> "First of all, it is about benefiting the least-advantaged people." *[NB1, male, 80]*

> "Above all, it is necessary to help retired individuals that need to be kept warm." *[TDS3, female, 53]*

Other respondents share the concern about the regressive impact of carbon taxes, but do not consider social cushioning as a viable option, due to its presumably large administrative burden. They thus seem to accept that carbon taxes would make some households relatively worse off:

> "To me, it seems too complicated." *[JRC1, male, 26]*

> "Really too complex and hard to realize." *[SB4, female, 46]*

> "Such system should not cost more than it yields." *[NB1, male, 80]*

These two types of answers represent however a minority. As discussed, for most respondents not using tax revenues for environmental purposes sounds inconceivable and groundless:

> "So, we go nowhere! If we pay more and give back part to others, the money goes nowhere! The target would be to invest for the future. Otherwise, we are stuck with fossil energy!" *[LRG1, female, 24]*

> "I do not see the link and I do not see why energy consumption would be used as a pretext to help the most affected households." *[TDS1, male, 23]*

> "If the revenues would be used for something different, the government would lose its credibility regarding how urgent the situation is. Actually, if it is so urgent and important to stop over-consuming, why should tax revenues be used for things other than saving the planet?! That is illogical." *[TDS4, female, 23]*

Finally, a few argue that there is clearly no need for social cushioning as it would benefit those already milking the welfare system:

> "It would be as always, with losers benefiting of these revenues." *[DM1, male, 30]*

> "There are already so many subsidies for poor people, and we should not mix up different problems." *[MG1, male, 25]*

Mixed opinions are reported on the recycling option consisting in tax rebates for households and firms. The support it receives arguably results from the perceived necessity to introduce a system of bonuses rewarding those curbing their energy demand, rather than from the quest of a double dividend (except for respondent JRC1). This may explain the popularity of bonus-malus policies and is clearly in line with the most recurrent critiques from the general public to the Environmental Tax Reform (ETR, see below).

> "Taxing is about making individuals aware of how dear is energy. This is to me the government's role, it could push it through the population by decreasing another tax." *[JRC1, male, 26]*

> "Using it as a bonus to reduce taxes to households and firms deserving it." *[MG3, male, 60]*

> "Households and firms that did an effort would deserve a tax rebate." *[KH2, female, 29]*

> "These revenues could actually allow to reduce taxes to those firms that get involved." *[MG1, male, 25]*

For those that do not like this option the explanation may reside once again in the missing link between taxation and the use of revenues, i.e. why taxing here and giving back there. A compelling interpretation is that for respondents NB2 and NB4, carbon pricing should not only redirect consumption towards cleaner goods and services, but also reduce the overall level of consumption, eventually leading to some degrowth.

> "Tax rebates do not make any sense. At the end, people could consume what they saved." *[NB4, male, 23]*

> "This would increase the purchasing power of households and the solution is actually reducing household's consumption." *[NB2, male, 23]*

4 Discussion and policy implications

Our qualitative evidence tends to confirm prior findings in the literature. We observe a general resistance to public intervention (as in Cherry et al., 2012) with, if deemed necessary, a preference for pull (e.g. subsidies to public transportation) over push (e.g. carbon tax) measures. For most respondents, private efforts represent the main approach to climate change mitigation and their effectiveness can be improved by the public sector through increased information and communication. Most of these efforts may come at a limited (or even negative) cost. The literature refers to "efficiency behaviour", which implies that with little effort the current level of comfort can be generally maintained, but at a lower level of energy consumption. Efficiency behaviour is opposed to "curtailment behaviour", which implies a change in lifestyle. Curtailment actions (such as the implementation of carbon taxes) are therefore much less popular than those targeting efficiency behaviour (Steg et al., 2006). Indeed, our analysis shows that a large cloud darkens the sky of carbon taxes: perception of environmental ineffectiveness and distrust in the government's real purpose are in our view two sides of the same coin. It follows that respondents are generally disconcerted about the possibility of using the revenues of an environmental tax for something unrelated to the environment (i.e. "issue-linkage", cf. Kallbekken and Aasen, 2010; but also e.g. Beuermann and Santarius, 2006; Steg et al., 2006; Brannlund and Persson, 2012). In this sense, it is because the carbon tax is perceived as ineffective that fiscal revenues have to be used in the environmental domain, otherwise the government would be simply seen as collecting extra revenues. Indeed, no other forms of recycling receive a tangible support. Not even social cushioning: although some respondents acknowledge the need to offset the tax's distributional effects, it seems that the way of financing social cushioning should make abstraction of carbon tax revenues (as in Kallbekken and Aasen, 2010).

Hence, we observe a gap between what economic theory suggests both in terms of policy choice, i.e. first-best versus second-best policies, and policy design, i.e. efficient use of revenues (e.g. allocation to the general budget ensuring flexibility and thus funding of policies with the highest social return or direct reduction of distortionary taxes) versus earmarking for environmental purposes (cf. Kallbekken and Aasen, 2010). We put forward several complementary explanations to this gap.

First, people may interpret the lack of private efforts as the result of a lack of information, whereas for economists analyse it is simply the standard outcome of a prisoner's dilemma. The call of respondents for improved communication may however somehow meet the recent strand of research on (conditional) cooperation in global dilemmas, see e.g. Cialdini (2003); Nyborg et al. (2006); Schultz et al. (2007); Ostrom (2009); Carattini et al. (2013); Lindman et al. (2013); Allcott and Rogers (2014).

Second, while for economists, in the short run and under standard assumptions, subsidies and taxes are equivalent in terms of incentives, the former are clearly preferred by the public. This preference is very well documented in the literature. As remarked by Steg et al. (2006), pull measures are perceived as more acceptable and more effective than push measures, unless revenues are allocated for environmental purposes (cf. also Kallbekken and Aasen 2010). Non-coercive instruments that make pro-environmental behaviour less costly are more appealing and considered as more effective as they are really perceived as an incentive, whereas taxes are seen more as a disincentive (or punishment), which unsuccessfully try to change people's lifestyle (cf. Steg et al., 2006). That is, as stressed in Carattini and Baranzini (2014), perceived effectiveness

and acceptability go hand in hand. The same seems to apply to our findings. Indeed, our results point to a diffused underestimation of carbon taxes environmental effectiveness. Respondents do not expect carbon taxes to be effective and this does not seem to be related to the panoply of exceptions and exemptions of existing carbon taxes, but rather to either a misunderstanding of carbon taxes' incentive effect or to a perception of fully inelastic demand of fossil fuels[2]. Therefore, it comes as no surprise that people confound Pigouvian with Ramsey taxes (cf. Kallbekken et al., 2011; Brannlund and Persson, 2012) and ask for earmarking revenues for environmental purposes. How could they have any environmental effect otherwise? That is, absent any earmarking, carbon taxes are perceived as a mere pretext to increase fiscal revenues. It is striking to see that this finding reconciles with those of studies focusing on the ETRs, which are generally fiscally neutral. Hence, perceived ineffectiveness and distrust in the government do not create the best premises for the implementation of carbon (or energy) taxes and above all of more elaborated schemes such as the ETRs (cf. Beuermann and Santarius 2006; Clinch and Dunne 2006; Clinch et al. 2006; Deroubaix and Lévèque 2006; Dresner et al. 2006a; Dresner et al. 2006b; Klok et al. 2006). Earmarking for environmental purposes is shown to substantially increase acceptability of carbon taxes also in Kallbekken et al. (2011), Kallbekken and Sælen (2011), Sælen and Kallbekken (2011) and Carattini and Baranzini (2014).

From this discussion three policy implications follow. First, when designing climate policies, policymakers may want to consider to give up some of the potential efficiency gains and trade them for increased clarity and thus acceptability. This would imply to earmark a substantial part of the revenues for environmental purposes, thus renouncing to e.g. some reduction in distortionary taxes, which economists tend to consider as the most productive use of revenues. This makes sense, since the general public do not fully understand the rationale for such an "obscure" mechanism. In this point we therefore agree with Grubb et al. (2014): earmarking should no longer be a taboo for economists, at least as a short-term measure to channel political support towards first-best policies. As a result, the criterion of revenue neutrality would not be met. Again, from a political perspective this is no harm, since for the general public neutrality does not seem to be a necessary requirement to support carbon taxes. Though, one may argue that in the case of a real ballot lobbies would react differently depending on the way revenues are used. Yet, we argue that most lobbying usually come from energy-intensive industries which would lose anyway, if climate policy really aims at allocating resources more efficiently, regardless of the use of revenues.

Second, since people seem particularly sensitive to their own gains, it would be useful to design policies in a way that makes them salient for those that may enjoy them. Emphasizing financial gains may make revenue-neutral policies much more appealing to the general public, thus contributing to bridge the gap between it and economists. Policymakers may want to build on the example of bonus-malus policies. These policies enjoy a relatively large support, probably because they make more explicit which behaviour is profitable and which is punished (cf. e.g. Dresner et al. 2006b). However, policies redistributing revenues lump sum act in the same way: small polluters are rewarded whereas big polluters end up with a net loss. The problem is that

[2]In the lab experiment of Kallbekken et al. (2011) giving to participants explanations on how the tax works do not improve acceptability. The authors suggest that this may be a feature of lab experiments, since assessing pay-offs is relatively easier than in real life. Our classroom discussions with students trained in economics (amongst others) may suggest instead that providing information may not be enough to change deep understanding and perception of Pigouvian taxes. In the case of Switzerland, estimates for gasoline price elasticity of demand range from -0.09 in the short run to -0.34 in the long run, cf. Baranzini and Weber (2013).

this mechanism is not made salient. The case of the Swiss carbon tax is particularly revealing. We emphasize the following two related elements. First, the population is not fully aware of the existing carbon tax on heating fuels (only 40% of the sample are aware of it in Carattini and Baranzini 2014). Second, redistribution is not salient at all. Using figures for 2014, the amount redistributed lump-sum to Swiss residents is 52.50 Swiss francs (about 42€). To keep administrative costs low, this is done through the compulsory healthcare insurance. However, no particular explanation is given about this refund, which is introduced in small characters in the monthly healthcare bill (i.e. the full amount is divided by 12). Even though the Swiss CO_2 levy is not yet completely revenue neutral, up to one third of revenues being allocated to improvements in energy efficiency in buildings, this feature could be easily marketed as a tax threshold (cf. Pezzey and Jotzo 2013) and thus be associated to a right to pollute, which would equal the lump-sum transfer times the current tax rate. Furthermore, financial gains may come with benefits of environmental nature (cf. Carattini and Baranzini 2014). In this respect, we stress emphasize the role played by the trial period in demonstrating the benefits of the Stockholm congestion charge and thus contribute to the policy success when people went to vote (cf. Kallbekken and Sælen 2011).

Third, in a shorter horizon, policymakers may want to develop those policies promoting voluntary efforts, which clearly do not face issues of acceptability, and then from them move on to more stringent policies. Policies targeting voluntary efforts may not necessarily need to take place at the national level. Subnational and local actors, which likely enjoy more trust by communities, may be more effective in spurring cooperation (Catney et al. 2013; Tavoni 2013). As shown by Blumer et al. (2014) for Switzerland, local utilities can have an important role to play in reducing energy consumption, provided that they are given the right incentives. In this respect it is of particular interest the choice of some utilities in several Swiss cantons to set the green electric mix as the default option. Even though users are in most cases given the possibility to opt out and move back to the "grey" option (thus saving a couple of cents per kWh), the evidence available so far indicates that only a few households take this chance while the large majority remains with the new default product. Arguably, such bottom-up approach would be more a complement than a substitute to top-down carbon pricing.

5 Conclusion

In the context of environmental issues in general and of climate change mitigation in particular, it is well known that the patient tends not to follow the doctor's prescriptions (cf. Hahn 1989; Brannlund and Persson 2012). The main reasons behind the limited diffusion of first-best policies seem to be related to their unpopularity. For most of the general public in this qualitative study, mitigation should mainly rely on voluntary efforts and public policy, if any, should be limited to encourage them through information, suasion and education. Market instruments such as subsidies or tax rebates may enjoy some degree of support, but carbon taxes do it only in a very limited extent. We assess qualitatively the drivers of this lack of public support and find them especially in the underestimation of carbon taxes environmental effectiveness. Perceived ineffectiveness goes hand in hand with distrust in the government, which is considered as looking for additional fiscal revenues only. In the case carbon taxes were to be implemented, since people do not understand or believe in their incentive effect, they would have to respond to a strong demand for earmarking fiscal revenues for environmental

purposes. Indeed, most people believe that carbon taxes curb emissions only indirectly by generating revenues to be invested in the environmental realm.

In terms of climate policy, our analysis suggests that complex schemes may better leave the place for straightforward policies with tax revenues alimenting a visible green fund, albeit this implies renouncing to efficiency-enhancing redistribution and revenue neutrality. Second, the public should be given the time to experience or the information to evaluate policy's benefits. Third, policies promoting private efforts may be easily implemented (and appreciated) as they would not face the barriers that carbon taxes do. Such policies may however not be sufficient for high abatement targets and their cost-effectiveness has to be ensured.

Acknowledgements

The authors would like to thank the staff and students of the Laboratory of Market Studies (LEM) at the Haute École de Gestion de Genève for their valuable support. We are also thankful to the participants to the 15$^{\text{th}}$ Global Conference on Environmental Taxation, Copenhagen, Denmark and SEPIA project fellows Philippe Thalmann, Frédéric Varone and Frank Vöhringer for precious comments and helpful discussion. Financial support from the Swiss Federal Office of Energy is acknowledged. The usual disclaimer applies.

References

Allcott, H. and Rogers, T. (2014). The short-run and long-run effects of behavioral interventions: Experimental evidence from energy conservation. *American Economic Review*, 104(10):3003–3037. 4

Baranzini, A. and Carattini, S. (2014). Taxation of emissions of greenhouse gases. In Freedman, B., editor, *Global Environmental Change*, Handbook of Global Environmental Pollution, pages 543–560. Springer Netherlands. 1

Baranzini, A., Goldemberg, J., and Speck, S. (2000). A future for carbon taxes. *Ecological Economics*, 32(3):395–412. 3

Baranzini, A., Thalmann, P., and Gonseth, C. (2004). Swiss climate policy: Combining VAs with other instruments under the menace of a CO_2 tax. In *Voluntary Approaches In Climate Policy*. Andrea Baranzini, Philippe Thalmann Ed. 1

Baranzini, A. and Weber, S. (2013). Elasticities of gasoline demand in Switzerland. *Energy Policy*, 63:674–680. 2

Baumol, W. J. and Oates, W. E. (1971). The use of standards and prices for protection of the environment. *The Swedish Journal of Economics*, 73(1):42–54. 1

Beuermann, C. and Santarius, T. (2006). Ecological tax reform in Germany: handling two hot potatoes at the same time. *Energy Policy*, 34(8):917–929. 4

Blumer, Y. B., Mühlebach, M., and Moser, C. (2014). Why some electricity utilities actively promote energy efficiency while others do not - a Swiss case study. *Energy Efficiency*, 7(4):697–710. 4

Brannlund, R. and Persson, L. (2012). To tax, or not to tax: preferences for climate policy attributes. *Climate Policy*, 12(6):704–721. 4, 5

Carattini, S. and Baranzini, A. (2014). Paying enough taxes already? Testing the acceptability of carbon taxes with survey data. SSRN Scholarly Paper ID 2461674, Social Science Research Network. 1, 1, 4

Carattini, S., Baranzini, A., and Roca, J. (2013). Unconventional determinants of greenhouse gas emissions: The role of trust. SSRN Scholarly Paper ID 2286025, Social Science Research Network. 4

Catney, P., Dobson, A., Hall, S. M., Hards, S., MacGregor, S., Robinson, Z., Ormerod, M., and Ross, S. (2013). Community knowledge networks: an action-orientated approach to energy research. *Local Environment*, 18(4):506–520. 4

Cherry, T. L., Kallbekken, S., and Kroll, S. (2012). The acceptability of efficiency-enhancing environmental taxes, subsidies and regulation: An experimental investigation. *Environmental Science & Policy*, 16(1):90–96. 1, 4

Cialdini, R. B. (2003). Crafting normative messages to protect the environment. *Current Directions in Psychological Science*, 12(4):105–109. 4

Clinch, J. P. and Dunne, L. (2006). Environmental tax reform: an assessment of social responses in Ireland. *Energy Policy*, 34(8):950–959. 4

Clinch, J. P., Dunne, L., and Dresner, S. (2006). Environmental and wider implications of political impediments to environmental tax reform. *Energy Policy*, 34(8):960–970. 4

Deroubaix, J.-F. and Lévèque, F. (2006). The rise and fall of French Ecological Tax Reform: social acceptability versus political feasibility in the energy tax implementation process. *Energy Policy*, 34(8):940–949. 4

Dresner, S., Dunne, L., Clinch, P., and Beuermann, C. (2006a). Social and political responses to ecological tax reform in Europe: an introduction to the special issue. *Energy Policy*, 34(8):895–904. 1, 4

Dresner, S., Jackson, T., and Gilbert, N. (2006b). History and social responses to environmental tax reform in the United Kingdom. *Energy Policy*, 34(8):930–939. 4

Frey, B. S. and Jegen, R. (2001). Motivation crowding theory. *Journal of Economic Surveys*, 15(5):589–611. 3

Goeschl, T. and Perino, G. (2012). Instrument choice and motivation: Evidence from a climate change experiment. *Environmental & Resource Economics*, 52(2):195–212. 3

Hahn, R. W. (1989). Economic prescriptions for environmental problems: How the patient followed the doctor's orders. *Journal of Economic Perspectives*, 3(2):95–114. 5

Huang, R. (2012). RQDA: R-based qualitative data analysis. R package version 0.2-3. 2

IPCC (2014). Climate change 2014: Mitigation of climate change. Technical report. 1

Kallbekken, S. and Aasen, M. (2010). The demand for earmarking: Results from a focus group study. *Ecological Economics*, 69(11):2183–2190. 4

Kallbekken, S., Kroll, S., and Cherry, T. L. (2011). Do you not like Pigou, or do you not understand him? Tax aversion and revenue recycling in the lab. *Journal of Environmental Economics and Management*, 62(1):53–64. 4, 2

Kallbekken, S. and Sælen, H. (2011). Public acceptance for environmental taxes: Self-interest, environmental and distributional concerns. *Energy Policy*, 39(5):2966–2973. 1, 4

Klok, J., Larsen, A., Dahl, A., and Hansen, K. (2006). Ecological tax reform in Denmark: history and social acceptability. *Energy Policy*, 34(8):905–916. 4

Lin, B. and Li, X. (2011). The effect of carbon tax on per capita CO_2 emissions. *Energy Policy*, 39(9):5137–5146. 1

Lindman, Å., Ek, K., and Söderholm, P. (2013). Voluntary citizen participation in carbon allowance markets: the role of norm-based motivation. *Climate Policy*, 13(6):680–697. 4

Marcantonini, C. and Ellerman, A. D. (2014). The implicit carbon price of renewable energy incentives in Germany. RSCAS Working Paper 2014/28, European University Institute. 1

Nyborg, K., Howarth, R. B., and Brekke, K. A. (2006). Green consumers and public policy: On socially contingent moral motivation. *Resource and Energy Economics*, 28(4):351–366. 4

OECD (2013). *Effective Carbon Prices*. Organisation for Economic Co-operation and Development, Paris. 1

Ostrom, E. (2009). A polycentric approach for coping with climate change. Policy Research Working Paper Series, The World Bank. 4

Pezzey, J. C. V. and Jotzo, F. (2013). Carbon tax needs thresholds to reach its full potential. *Nature Climate Change*, 3(12):1008–1011. 4

Sælen, H. and Kallbekken, S. (2011). A choice experiment on fuel taxation and earmarking in Norway. *Ecological Economics*, 70(11):2181–2190. 1, 4

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., and Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science*, 18(5):429–434. 4

Steg, L., Dreijerink, L., and Abrahamse, W. (2006). Why are energy policies acceptable and effective? *Environment and Behavior*, 38(1):92–111. 4

Steg, L. and Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology*, 29(3):309–317. 3

Tavoni, A. (2013). Game theory: Building up cooperation. *Nature Climate Change*, 3(9):782–783. 4

Thalmann, P. (2004). The public acceptance of green taxes: 2 million voters express their opinion. *Public Choice*, 119(1-2):179–217. 1

World Bank (2014). State and trends of carbon pricing 2014. Technical report. 1

A Socio-demographic characteristics

ID	Length	Gender	Age	Postal code	Job profile	Income class	HC
DM1	28	M	30	1226	-	middle-low	tenant
DM2	32	F	65	1205	retiree	low	tenant
DM3	22	F	30	1226	worker	middle-high	-
DM4	28	F	34	1227	worker	middle-low	tenant
JRC1	27	M	26	1219	worker	middle-low	tenant
JRC2	24	F	56	1228	worker	middle-low	tenant
JRC3	23	M	29	1227	worker	low	tenant
KH1	25	M	25	1202	student	middle-low	tenant
KH2	30	F	29	1203	worker	middle-low	owner
KH3	25	M	25	1203	student	low	tenant
KH4	21	M	27	1290	worker	middle-low	tenant
LRG1	20	F	24	1226	student	low	tenant
LRG2	30	F	32	1227	worker	middle-high	tenant
LRG3	19	F	30	1227	worker	low	tenant
LRG4	40	M	35	1207	worker	middle-low	tenant
MG1	22	M	25	1207	worker	middle-low	tenant
MG2	24	M	31	1207	unemployed	middle-low	tenant
MG3	15	M	60	1207	retiree	middle-high	tenant
MG4	25	F	58	1207	retiree	middle-high	tenant
NB1	45	M	80	1228	retiree	middle-low	owner
NB2	45	M	23	1228	worker	middle-low	tenant
NB3	40	F	20	1227	student	middle-low	tenant
NB4	35	M	23	1205	student	low	tenant
PJB2	*NA*	M	22	1252	independent	low	tenant
PJB3	15	F	47	1206	independent	high	owner
PJB4	35	F	26	1227	student	low	tenant
SB1	20	F	46	1201	worker	middle-low	tenant
SB2	23	F	24	1202	worker	low	tenant
SB3	30	M	57	1201	worker	middle-high	tenant
SB4	25	F	46	1201	worker	middle-low	tenant
SC1	30	F	30	1227	independent	middle-high	tenant
SC2	25	M	30	1294	worker	low	owner
SC3	30	M	23	1255	student	high	owner
SC4	35	F	36	1292	manager	high	owner
TDS1	30	M	23	1205	student	middle-low	tenant
TDS2	35	M	29	1227	worker	middle-high	tenant
TDS3	35	F	53	1201	worker	middle-low	owner
TDS4	25	F	23	1227	student	middle-low	tenant

Note: Lenght of interview measured in minutes. HC stands for "housing contract".

Table A.1: Socio-demographic characteristics

Cahiers de recherche du Centre de Recherche Appliquée en Gestion (CRAG) de la Haute Ecole de Gestion - Genève

CRAG - Centre de Recherche Appliquée en Gestion
Haute école de gestion - Genève
Campus de Battelle, Bâtiment F
7, route de Drize - 1227 Carouge - Suisse
crag@hesge.ch
www.hesge.ch/heg/crag
+41 22 388 18 18
+41 22 388 17 40

Tous les cahiers de recherche de la HEG sur RERO DOC :
http://doc.rero.ch

Annex 4

Environ Econ Policy Stud
DOI 10.1007/s10018-016-0144-7

RESEARCH ARTICLE

Effectiveness, earmarking and labeling: testing the acceptability of carbon taxes with survey data

Andrea Baranzini[1] · **Stefano Carattini**[1,2]

Received: 3 June 2015 / Accepted: 21 January 2016

Abstract This paper analyzes the drivers of carbon taxes acceptability with survey data and a randomized labeling treatment. Based on a sample of more than 300 individuals, it assesses the effect on acceptability of specific policy designs and individuals' perceptions of carbon taxes advantages and disadvantages. We find that the lack of perception of primary and ancillary benefits is one of the main barriers to the acceptability of carbon taxes. In addition, policy design matters for acceptability and in particular earmarking fiscal revenues for environmental purposes can lead to larger support. We also find an effect of labeling, comparing the wording "climate contribution" with "carbon tax". We argue that proper policy design coupled with effective communication on the effects of carbon taxes may lead to a substantial improvement in acceptability.

Keywords Climate policy · Carbon tax · CO_2 emissions · Political economy

JEL Classification D72 · H23 · Q48 · Q52 · Q58

✉ Stefano Carattini
stefano.carattini@hesge.ch

Andrea Baranzini
andrea.baranzini@hesge.ch

[1] Haute école de gestion de Genève, HES-SO, University of Applied Sciences Western Switzerland, 7, route de Drize, Carouge, 1227 Geneva, Switzerland

[2] Grantham Research Institute on climate change and the environment and ESRC Centre for Climate Change Economics and Policy, London School of Economics and Political Science (LSE), Houghton Street, London WC2A 2AE, UK

Published online: 24 February 2016

1 Introduction

In recent decades, international negotiations have aimed at stabilizing the concentration of greenhouse gases at levels that would prevent dangerous interferences with the climate system. However, there is increasing evidence showing that current mitigation efforts are by large not enough (UNEP 2013; IPCC 2014). This result comes as no surprise. Even though economists assessed their theoretical cost-effectiveness long time ago (cf. e.g. Baumol and Oates 1971), the implementation of powerful policy instruments to reduce greenhouse gas emissions such as carbon taxes is a rather recent phenomenon (Baranzini and Carattini 2014). A recent strand of literature has started exploring the public acceptability of carbon taxes, pointing to a series of important obstacles such as distributional impacts on low-income households and fear of competitiveness effects (cf. Baranzini et al. 2000; Zhang and Baranzini 2004). In most developed countries carbon taxes are indeed at least slightly regressive (see e.g. Roca and Serrano 2007; Brännlund and Ghalwash 2008; Sterner 2011) and the local co-benefits benefitting mostly the poorest households are usually given a lower weight. Despite the recent empirical evidence points to rather small competitiveness effects (Mathys and de Melo 2011), potential adverse effects on employment and competitiveness represented a real concern when the first carbon taxes in Scandinavian countries were designed (cf. e.g. Godal and Holtsmark 2001; Bruvoll and Larsen 2004) and when similar schemes were turned down elsewhere (cf. e.g. Thalmann 2004).

More recently, the literature has devoted increasing attention towards the perceived impact of carbon taxes on the environment. While economists tend to take the beneficial environmental effects as granted, the effectiveness of carbon taxes does not seem to be always internalized by the general public. Based on qualitative assessments, Dresner et al. (2006) first raised the issue of perceived environmental ineffectiveness: the general public tends to miss the incentive effect of carbon taxes, thus expecting tax revenues to be earmarked for environmental purposes. When this is not the case, most people feel that carbon taxes are just a pretext to raise fiscal revenues. When tax revenues are earmarked for other purposes, the general public is generally disconcerted about the possibility of using the revenues of an environmental tax for something unrelated to the environment. Sælen and Kallbekken (2011) define this problem as "issue-linkage". The stylized fact of Dresner et al. (2006) is supported by the quantitative evidence of Kallbekken and Sælen (2011) and Sælen and Kallbekken (2011), both finding a negative pattern between perceived environmental ineffectiveness and stated support for carbon and energy taxes, and is consistent with real voting behavior as analyzed by Thalmann (2004). Pigouvian taxes are thus perceived at the same time as coercive and ineffective (Steg et al. 2006). This may lead Pigouvian taxes to be more popular if not labelled as such: in the lab experiment of Kallbekken et al. (2011), a "fee" is preferred to an equivalent instrument called "tax".

We improve this recent literature using survey data and a randomized labeling treatment to test the effect of several policy variables and perceptions on acceptability. First, we confirm that perceived environmental ineffectiveness is

one of the main barriers to the acceptability of carbon taxes. Our original approach shows that not only the expectation of main environmental effects affects acceptability, but also the perception of potential co-benefits does. Second, we show that competitiveness and distributional effects may not have a role as determinants of acceptability. Third, we show that acceptability increases substantially with earmarking, in particular for environmental purposes. This is especially true among those individuals who tend to distrust the government. However, earmarking does not act as a substitute for perceived effectiveness. Even when revenues are earmarked, perceived effectiveness remains related to higher acceptability. Fourth, contrasting the labels "carbon tax" and "climate contribution", we show that labeling can spur acceptability also in the street and not only in the lab. "Climate contribution" may sound as an appeal to the public good, recalling to the general public the urgency of climate change mitigation.

We use the Canton of Geneva, Switzerland, as field, and interview more than 300 individuals between December 2012 and January 2013. The Swiss context may be particularly salient to simulate voting behavior, since Swiss people are used to express their opinions in poll and ballots, but we consider all of our findings of general interest. The lack of popularity of carbon taxes has indeed limited its implementation in virtually all political contexts in developed countries.

2 Survey design and data description

2.1 Hypotheses

We formulate a series of main hypotheses to be tested with the econometric model.

We expect positive perceived impacts of carbon taxes to be positively associated to carbon tax acceptability. Positive impacts consist of carbon emissions abatements (i.e. environmental effectiveness) and improvements in local outcomes such as air quality, health and road externalities. As shown by Dresner et al. (2006) and Bristow et al. (2010), the acceptability of a given carbon tax design can be influenced by how agents perceive the instrument as effective (see also Brouwer et al. 2008 on a carbon travel tax). We are not aware of previous studies examining the link between perceived co-benefits and acceptability, but Longo et al. (2012) suggest for instance that the willingness to pay for climate change mitigation is about 50–70 % higher when co-benefits are considered by respondents.

Concerning drawbacks, distributional concerns affect acceptability in Thalmann (2004), in which the probability of a yes-vote for a green proposal is substantially lower when the proposal implies a clear increase in inequalities. Bristow et al. (2010) find a marked preference for a carbon credit up to 4 tons of CO_2 per capita to reduce distributional effects. Inequality aversion is also present in Kallbekken and Sælen (2011) and Brannlund and Persson (2012).

Acceptability is supposed to increase with earmarking and we expect earmarking for environmental purposes to have the largest impact (cf. e.g. Dresner et al. 2006; Steg et al. 2006; Kallbekken and Aasen 2010; Sælen and Kallbekken 2011). When earmarking is not specified, we expect people distrusting the government to be less

likely to approve carbon taxes. Since most people fail to understand the difference between Pigouvian and Ramsey taxes and thus perceive environmental taxes as a mean to raise more revenues (Kallbekken et al. 2011), they may be willing to give up some of their income only if the use of revenues is clearly made explicit. Because the tax is perceived as environmentally ineffective, the only way to impact the environment is by earmarking the fiscal revenues for the environment.

Based on the literature, we forecast different acceptability depending on the labeling of the tax. According to Steg et al. (2006), environmental taxes are perceived by most of the general public as "penalties", i.e. coercive measures imposing a change in behavior. Higher acceptability with different labeling is found not only in Kallbekken et al. (2011), but also in the online choice experiment of Brannlund and Persson (2012), in which a policy called "tax" is opposed to another policy simply framed as "other". To make the contrast even more manifest, in our survey we opt for the labeling "climate contribution" as opposed to "tax". We expect "climate contribution" to sound as an appeal to the public good, which may crowd in motivation as predicted by persuasive advertising models as in Becker and Murphy (1993) and Nyborg et al. (2006). "Climate contribution" may signal that the climate as we know it (i.e. the status-quo) requires help, whereas a "tax" may recall a threat to disposable income (cf. e.g. Kahneman and Tversky 2000).

Finally, we recall that most of the general public would not tackle climate change as economists would, i.e. with first-best economic instruments. Indeed, "non-coercive" policies enjoy much higher acceptability. Hence, people not considering carbon taxes as a priority to cope with climate change are expected to be less supportive of this instrument and the other way round. In sum, the hypotheses that we test in Sects. 3.1 and 3.2 are the following:

H1 Perceived positive (negative) effects of carbon taxes positively (negatively) affect carbon tax acceptability. Positive effects consist not only in emissions abatements but also of local co-benefits.

H2 Earmarking revenues increases acceptability, especially for environmental purposes.

H3 The support to carbon taxes of people not trusting the government is especially dependent on the use of revenues.

H4 The label "climate contribution", as opposed to "carbon tax", generates more support.

H5 Most people do not see carbon taxes as the main solution to curb greenhouse gas emissions. These people are less likely to support carbon taxes.

To test these hypotheses, we administer face to face a questionnaire pre-tested and supported by a qualitative study (see Sect. 2.3) to random people in the streets of Geneva. In an experimental spirit, we test for hypothesis H4 by administering two types of questionnaire: half of the sample was randomly attributed a questionnaire with the wording "carbon tax" (hereafter CT), while the remaining with "climate contribution" (CC).[1]

[1] Cf. Appendix 1 for the full questionnaires.

2.2 Economic context

From a climate policy perspective, the context of Switzerland is of particular interest. Switzerland lobbies beside the European Union in the post-Kyoto negotiations, urging for ambitious agreements. In addition, in the aftermath of the Fukushima accident, Switzerland decided to start to phase-out nuclear energy. Since currently 40 % of electricity is from nuclear sources, Switzerland has very low carbon emissions from electricity in international comparison and thus little room for maneuver to replace nuclear energy without increasing carbon emissions. This implies the need for substantial reductions in consumption (Baranzini et al. 2013).

Given the public rejection of three energy-tax proposals in 2000, Switzerland adopted a climate strategy based on voluntary agreements and only in 2008 introduced a carbon tax limited to heating fuels (cf. Thalmann 2004; Baranzini et al. 2004). After that Switzerland missed in 2012 its objective of CO_2 emissions reduction, the carbon tax rate was revised upward, but an extension of the tax base to all fuels may be desirable to reach the more ambitious abatement targets currently under consideration.[2] In particular we refer to the pledge that Switzerland submitted to the UNFCCC in February 2015 in view of the same year's Conference of Parties, consisting in a reduction of emissions of 50 % by 2030 with respect to the levels of 1990. Doing so, Switzerland became the first country to submit a pledge and set the bar high for the following participants.

Energy taxes are already a hot topic in Switzerland. In March 2015, the Swiss population rejected at 92 % (90.9 % in the Canton of Geneva) an extremely ambitious popular initiative promoted by the Green Liberals aiming at completely replacing the current value-added tax (VAT) with an energy tax. Given the substantial dependence of the Swiss government from VAT revenues and the concern that energy prices would have spiked well beyond what currently under consideration by policymakers, the promoters of the initiative found themselves practically isolated and with the government taking position against the initiative. While the Swiss government opposed the specific proposal brought up by the Green Liberals, it does support the principle of economic incentives and in particular of generalized carbon taxes. Shortly after the vote, the Swiss government announced its plan for reaching the abovementioned targets, which indeed relies on carbon taxation of all fuels (with a short embargo on gasoline) and lump-sum redistribution of revenues. In line with the findings of this paper, the Swiss government interprets the March 2015's vote as a rejection of the Green Liberals' proposal and not of carbon taxes per se.

2.3 Qualitative survey

To define the questions of the quantitative survey, we first administer through semi-structured interviews a qualitative survey to a small and unrepresentative sample of

[2] The reference tax rate at the time of the study was 60 CHF per ton of CO_2, but the government could increase it up to 120 CHF/tCO_2 if deemed necessary. As of May 2015, 1 CHF $\approx$ 1.05 USD $\approx$ 0.95 EUR. Two thirds of revenues are redistributed lump sum to households and through lower social contributions to firms. The remaining third is allocated to energy-efficiency investments in the building sector.

about 40 adults living in the Canton of Geneva. The interviews took place between October 26th and November 26th 2012. We report the main findings. First, private actions (e.g. improvements in energy efficiency) are preferred to public intervention to curb energy consumption and emissions. Second, when interviewers introduce explicitly the role of the public sector, the general opinion is to limit its intervention to communication and education (i.e. suasion). Market instruments are mentioned only by few, and subsidies (e.g. for public transportation) are by large preferred to taxes, as in Cherry et al. (2012).

Third, interviewers face some resistance when they propose the implementation of a generalized carbon tax, related to distrust in the government and a presumed ineffectiveness in changing behavior. It follows that when they ask how tax revenues should be used, most respondents suggest to keep them in the environmental domain. Fourth, social cushioning for low-income households is regarded as important, but it seems that the way of financing it should be independent of the environmental tax revenues.

2.4 Quantitative survey

2.4.1 Sample properties

We administer the quantitative survey between December 14th 2012 and January 14th 2014. Our sample is composed of 338 valid observations, 158 in the CT and 180 in the CC sub-samples. Respondents are recruited in the street, with the CT and CC questionnaires being randomly allocated to interviewers and thus interviewees. The composition of the sample is fairly representative of Geneva population, except for a slight under- (over-)representation of retired (young) and less educated individuals. Based on the socioeconomic characteristics of Table 3, we compare the CT and CC sub-samples. We do not find any statistical differences in the averages of these variables, except in the case of education (16 years with CT compared to 15.59 with CC) and the number of adults in the households (2.15 with CT and 2.44 with CC). Even though most of our insights are driven by internal validity, we are also concerned by the external validity of our results. The econometric approach of Sect. 3 takes thus care of possible sample selection.

The survey also identifies members of environmental organizations (hereafter "green members", 14 % of the sample) and political positioning (coded as left, center, right and no positioning), and investigates general measures of self-reported environmental concern. It also asks whether respondents generally trust their government and if they are aware of the existing CO_2 tax on heating fuels. Most of the people in the sample do trust the government as 93 % declare to be either "rather confident" or "completely confident" with respect to the government's deeds. Remarkably only 40 % declare to be aware of the current carbon taxation. The lack of awareness concerning current taxation may be explained by the limited salience of both taxation and lump-sum refunds to households through reduced healthcare bills. Respondents are also asked what role they would attribute to the public sector to spur energy conservation. Only a tiny fraction of individuals (2 %) contends that there is no need for energy conservation at all. Similarly, only 3 %

believe that energy consumption does not need to be regulated. That is, the large majority expects the government to intervene to curb energy consumption. However, as for the qualitative survey, market instruments do not represent the favored tool. Preferences go rather to informational campaigns raising awareness and to policies funding public transportation. However, already at this stage 35 % of respondents believe that the Swiss government should intervene with a broader carbon tax to lower energy consumption.

2.4.2 Policy variables

In what follows we present the main policy variables included in the survey (cf. Table 5 for the full descriptive statistics).

Carbon taxes' environmental effectiveness In the survey, we introduce a hypothetical carbon tax (or climate contribution) with a tax rate of 120 CHF per ton of CO_2, implying a price increase of gasoline of about 15 % and of heating fuel of about 30 %. The majority of the sample thinks that the tax would lead to a reduction of their level of energy consumption, but a non-negligible proportion of respondents (37 %) expects no change in behavior. A small minority (7 %) even expects larger consumption. These either represent protest answers or suggest that worries of a possible motivational crowding-out may be justified. That is, economic instruments may turn out to have counterproductive effects on intrinsically motivated agents (Deci and Ryan 1985), if individuals that already provide large efforts for a given public good in the absence of any economic incentive feel frustrated for being taxed despite their efforts ("no behavior is good enough not to be penalized", Goeschl and Perino 2012) or feel less responsible toward the provision of the public good as they think that "since I pay, I can consume and thus pollute" (Bazin et al. 2004).

Next, the questionnaire enlarges the focus and asks whether people expect the tax to be effective, i.e. if it would lead to a decrease in the energy consumption and greenhouse gas emissions of Switzerland. A short majority (52 %) expects the tax not to be effective.

Co-benefits Respondents are asked to spontaneously mention a list of ancillary benefits of carbon taxes, if any, without having access to the list of potential answers in the questionnaire, to avoid to influence their opinions. About half of the sample (56 %) expects better air quality as an ancillary benefit from carbon taxes. The proportion is lower for congestion issues (27 %), health improvements (42 %) and road accidents (18 %). People thus exhibit a relatively low awareness of co-benefits, which may need to be targeted through improved communication, along with primary benefits.

Disadvantages In line with the literature, regressive effects seem to represent a real issue for the people in this sample. However, we find that only a minority (25 %) is concerned about distributional effects on rural households, which are also expected to be particularly affected, given the limited possibilities of substitution between private and public transportation in the countryside. This may be specific to the

context of Geneva, whose countryside hosts many high-income households attracted by calmness, green spaces and possibly low income tax rates. Instead, only relatively small proportions of respondents are concerned about employment and competitiveness effects. In particular, the number of people concerned about employment issues (11 %) is only slightly larger than those concerned about their own job (5 %; the correlation between being concerned about unemployment and being concerned about the own job is 0.46). We note that at the time of the survey, the level of unemployment in the Canton of Geneva (in Switzerland) was about 5.5 % (3 %).

Finally, one of the main perceived drawbacks is represented by the private cost of climate change mitigation, which is strictly positive for all citizens absent any redistribution. The most generalized fear for respondents in this sample (67 %) is to be constrained to reduce the overall level of consumption due to the higher energy prices. Interestingly, expecting lower purchasing power does not necessarily imply a loss of comfort. It appears that people in the sample feel that they could live comfortably even with less purchasing power, although they may not like it. Further data inspections show that expecting losses of purchasing power is negatively correlated with the highest income category and expecting less comfort is positively associated with the lowest income category.

Acceptability After discussing policy's advantages and disadvantages, we directly test for policy acceptability. No earmarking is specified at this stage, i.e. tax revenues fund the general budget, which is the first best from an economic perspective (cf. Sælen and Kallbekken 2011). The share of positive answers is quite high and close to majority (49 %). In fact, the approval rate is very close to the support given to the "Energy conservation package" in the ballot of 2000 (46.6 %, cf. Thalmann 2004).[3]

Social cushioning The questionnaire then asks what groups of population should be compensated due to the CT/CC perceived adverse impacts. Social cushioning is particularly warranted for low-income households (72 % of support), but around 50–60 % of respondents support also compensating measures for elderly people and large families. We stress that retiring implies lower income (60 % of pre-retirement income is the social security target in Switzerland) and pensions are not indexed to inflation. In the United Kingdom, for instance, lump-sum transfers are done in favor of people aged 62 or more under the Winter Fuel Payment scheme. However, cushioning of these two categories is seldom mentioned in the literature.

Societywide refunds, i.e. the current way of refunding tax revenues from the Swiss carbon tax on heating fuels, seems not to be the preferred option for our sample, although it represents a simple and cheap (but also possibly ununderstood) way of reducing regressivity (see e.g. Metcalf 2009; cf. Pezzey and Jotzo 2013 and Bristow et al. 2010 on tax thresholds). In particular, we remark that older people are

[3] Respondents were also given a "Do not know" option. However, what we want to assess is the willingness to accept such a policy and hence treat irresolute respondents as no-voters, although abstention is always an alternative in ballots. 93 individuals are concerned.

disadvantaged by the current recycling, while the opinions in this sample would rather justify a specific aid to this sub-population.

Revenue recycling We propose three ways of revenue recycling (and give space for a possible fourth option). The first option is redistribution towards affected households, which relates to the previous discussion on distributional effects. The second option consists in tax rebates for households and firms, which may allow, by decreasing distortionary taxes, for the double dividend of environmental taxation. Earmarking tax revenues for environmental purposes is a recurrent and popular option in the literature and represents the third alternative. Respondents are asked to rank the alternatives in decreasing order of preference. Unsurprisingly, 60 % of the respondents would like to see the tax revenues used to finance environmental projects. Social cushioning comes second, while tax rebates to households and firms are supported by a small minority only.

Acceptability conditional on recycling We retest the level of acceptability conditional on earmarking and revenue recycling. In detail, the survey asks whether the respondent would accept a CT/CC if revenues were to be recycled according to her preferred recycling option. Yes-votes reach now 64 %, i.e. about 15 % more than without earmarking. This result is consistent with the literature. This level of support may however be misleading since obtained by assuming that the preferred recycling options of each individual can be implemented simultaneously. We also stress the relative importance of the residual 36 % of respondents for which earmarking revenues is not sufficient to have them accepting the CT/CC, at least at the tax rate proposed by the questionnaire. Econometric analyses are performed in Sect. 3.

Tax rate So far, the questionnaire refers to a CT/CC with a tax rate of 120 CHF/tCO_2, causing with full pass-through an increase of about 15 % (30 %) in the price of gasoline (heating fuels). The questionnaire, thus, asks to the respondents what would be their highest acceptable CT/CC tax rate, expressed in terms of energy price increases. The aim is to measure the intensity of acceptability. The distribution of answers is bounded by the minimum and maximum possible answers given in the questionnaire (0 and 30 %) and centered in the 5–10 % interval (using interval means, the average is 7 % and the median 7.5 %). Hence, albeit 64 % of the sample supports the tax in the previous question, when asked about defining themselves the tax rate, respondents tend to indicate more moderate energy price increases than what proposed by the survey. The two results are not necessarily in contradiction. Voters are indeed supposed to select the option that is closer to their preferences. In this respect, the Norwegian choice experiment of Sælen and Kallbekken (2011) shows that respondents would prefer to decrease the current level of environmental taxes, absent earmarking for environmental purposes. In a similar spirit, Godal and Holtsmark (2001) suggest to always start with a low tax rate and increase it regularly once the policy is in place.

3 Econometric analysis, results and discussion

3.1 Carbon tax acceptability

In this section, we analyze the determinants of carbon tax acceptability when earmarking is not specified. Since the outcome variable is binary, we apply a probit estimation strategy. We use as controls both socioeconomic characteristics and the policy perceptions presented in the previous section. Several socioeconomic factors are possible determinants of the demand for environmental policy in general and climate change mitigation in particular. We obtain from our survey data on e.g. income, education, age, gender, car holding (as proxy for carbon footprint, see Thalmann 2004; Kallbekken and Sælen 2011; Diederich and Goeschl 2013) and membership of environmental organizations (as proxy for pro-environmental behavior).

Estimations results are reported in Table 1, based on marginal effects at median, consistently with the median voter theorem.[4] Column (1) starts with socioeconomic characteristics.

Given the many missing values and its statistical non-significance, income is excluded. A variable taking value 1 if income is missing would also be non-significant. The absence of an effect of income is in line with the literature on environmental ballots (see e.g. Deacon and Shapiro 1975; Thalmann 2004; Bornstein and Lanz 2008) and fits the theoretical prediction, above all in a global context in which the demand for environmental quality is likely to be only partially expressed (cf. Roca 2003).

Some other socioeconomic variables are clearly not significant. We do not find for instance any statistically significant effect for age (both as a continuous variable or using specific groups such as e.g. youth, retired people), gender and political positioning.

Column (1) shows that the number of cars held by respondents is negatively and significantly linked with the probability of accepting a carbon tax, whereas green membership and education have a positive impact. That is, as in Thalmann (2004), it is not only car ownership, but also the number of vehicles that is related to political behavior. Of course, ecologists are expected to be relatively more in favor of climate policy tightening. The effect of education is also as predicted. Since education is a long-run investment, educated people may possess a lower discount rate than the average citizen, according to Bornstein and Lanz (2008). Moreover, educated people may suffer of lower informational gaps on climate change issues.

[4] Marginal effects are derivatives computed in different ways depending on the assumed underlying distribution. Probit assumes a normal (Gaussian) distribution. We compare marginal effects at median with marginal effect at mean, average marginal effects, logit (which allows for "thicker tails") and OLS. Marginal effects at mean and average marginal effects are qualitatively unchanged with respect to the estimates presented in the tables (estimates not provided here). We find that for most coefficients the choice of the econometric model has implications for the interpretation in terms of magnitude, but not of sign and significance. In a few specifications co-benefits turn out to be non-significant. Given the presence of heteroscedasticity, the estimated model includes a heteroscedastic error term. Standard errors are computed with the Delta method (cf. Greene 2011). We report estimations for our preferred models, but the insights provided in this section generally hold also with the alternative specifications.

Table 1 Testing carbon tax/climate contribution acceptability: marginal effects at median from probit estimation

Acceptability when earmarking is not specified	(1)	(2)	(3)
Number of cars	−0.0935** (0.0411)	−0.0540* (0.0323)	−0.0641* (0.0340)
Green member	0.267*** (0.0790)	0.212** (0.0943)	0.196** (0.0925)
Years of education	0.0286* (0.0162)	0.0144 (0.0159)	0.0166 (0.0173)
Gender (male)	0.0827 (0.0589)		
Number of adults in the household	0.0284 (0.0283)		
Homeowner	0.0437 (0.0853)		
Age	0.000629 (0.00227)		
Unemployed	−0.0596 (0.189)		
Left	0.134 (0.0836)		
Center	0.0681 (0.0786)		
Right	−0.0533 (0.0902)		
Climate: high concern		0.164*** (0.0616)	0.146** (0.0673)
Energy consumption: no attention		−0.339*** (0.126)	−0.377*** (0.097)
Energy consumption: very attentive		−0.0483 (0.0785)	
Expected cooperation		0.110* (0.0624)	0.0675 (0.0665)
Trust in the government		0.200* (0.112)	0.129 (0.133)
Government intervention: information		0.103 (0.0707)	0.126* (0.0708)
Government intervention: taxation		0.267*** (0.0635)	0.234*** (0.0693)
Government intervention: subsidies		0.0144 (0.0649)	
Government intervention: none		0.0861 (0.211)	
CT/CC: effect on own behavior			0.186** (0.0734)
CT/CC: crowding-out or protest answers			−0.0311 (0.128)
CT/CC: environmental effectiveness			0.283*** (0.0672)
CT/CC: co-benefits			0.0387** (0.0174)
CT/CC: drawbacks (less purchasing power)			−0.165** (0.0778)
CT/CC: drawbacks (less comfort)			−0.0286 (0.0663)
CT/CC: drawbacks (fear of losing job)			−0.237 (0.172)
CT/CC: drawbacks (distributional effects on the poor)			−0.096 (0.0658)
CT/CC: drawbacks (distributional effects on rural)			−0.0966 (0.0773)
CT/CC: drawbacks (competitiveness effects)			−0.0702 (0.0843)
CT/CC: drawbacks (employment effects)			−0.0352 (0.123)
Labeling (climate contribution)			−0.1253 (0.1799)

Table 1 continued

Acceptability when earmarking is not specified	(1)	(2)	(3)
Pseudo R^2	0.075	0.175	0.282
Log pseudolikelihood	−205.772	−185.675	−161.774
N	321	325	325

Robust standard errors in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

H_0: all β equal to zero. In column (1) $\text{Chi}^2(11) = 37.03$, $p = 0.0001$. In column (2) $\text{Chi}^2(12) = 62.43$, $p = 0.0000$. In column (3) $\text{Chi}^2(21) = 95.10$, $p = 0.0000$

Lack of information could downplay the relative benefits of climate change mitigation (cf. e.g. Cohen and Viscusi 2012). The coefficient of column (1) implies that an additional year of education is linked with about 3 % more probability of accepting the tax, thus mirroring the evidence on ballots (cf. Thalmann 2004; Sciarini et al. 2007; Bornstein and Lanz 2008; Bornstein and Thalmann 2008; Stadelmann-Steffen 2011) and on the demand for climate change mitigation (see e.g. Roe et al. 2001; Achtnicht 2012; Loeschel et al. 2013).

In column (2) we introduce variables on environmental attitudes. This allows us to test the hypotheses H3 and H5. We find that being a priori in favor of a carbon tax has a very large effect on acceptability. This confirms H5 and provides evidence for the internal validity in the questionnaire. As expected, trust in the government engenders higher acceptability, providing first evidence in favor of H3.

We also find that being highly concerned about the climate and paying no attention to energy consumption have a significant and economically meaningful impact on acceptability, consistently with Kallbekken and Sælen (2011). Since the effect of education disappears once introduced the role of information and concern, we may suggest that its effect is rather driven by information asymmetry than a difference in discounting. Expectation of cooperation in energy conservation's efforts from fellow-citizens is associated with a positive effect on acceptability. This result suggests that people's willingness to contribute to climate change mitigation may depend on others doing the same, a result increasingly found in the literature (see Carattini 2015 for a detailed review). For instance, using different treatments Bolsen et al. (2014) show that the propensity of American students to be in favor of a carbon tax depends positively on the same propensity for the whole population as reported in polls. In the same vein, Lindman et al. (2013) find that Swedish students show larger willingness to pay for climate change mitigation when provided with information suggesting a very high participation of the Swedish population in voluntary carbon offsetting activities. From a theoretical perspective, these findings, including ours, point to conditional cooperation in the climate commons (see Nyborg et al. 2006). As suggested by Ostrom (2009), individuals may be willing to contribute to a public good such as climate change mitigation if they expect others doing the same, and this in spite of the global public good property of climate change. Hence, trust may contribute to overcome some of the incentives to free ride not only in local environmental dilemmas, but also in global commons, such as

climate change. In this respect, we refer to the recent empirical evidence providing support in favor of Ostrom (2009), with trust being negatively associated to greenhouse gas emissions (Carattini et al. 2015) and trust being positively correlated with the probability of implementing local sustainable policies under the Agenda 21 scheme (Owen and Videras 2008).

Column (3) introduces the policy variables. The coefficients of column (2) are generally robust to this new specification. "Government: information" now reaches significance, suggesting the perception of a complementarity between information and taxation. According to the focus group of Kallbekken and Aasen (2010), the general public feels that information campaigns should accompany the implementation of climate policy providing knowledge on its instruments and not only raising awareness on climate change (see also Nyborg et al. 2006; Brannlund and Persson 2012).

Column (3) allows us to further test our main hypotheses. The effects related with environmental effectiveness and perceived co-benefits are striking and partly confirm H1. If the tax is expected to be effective in reducing emissions, acceptability rises by about 30 %. The impact of co-benefits on acceptability has a similar magnitude, since this variable ranges from 0 to 8. Hence, our findings strongly support the literature on the perceived effectiveness of carbon taxes and provide a quantitative estimate of the magnitude of its linkage with acceptability, which is shown to depend also on perceived co-benefits.[5]

Neglecting co-benefits would clearly imply an overestimation of the net policy costs, since most studies providing monetary estimates of co-benefits suggest that they are relatively conspicuous compared to mitigation costs, also in the case of Switzerland and other developed countries (cf. e.g. OECD 2014). In fact, co-benefits are in the order of several tens of dollars per ton of CO_2 and may well exceed abatement costs (Baranzini and Carattini 2014). According to Pittel and Rübbelke (2008), co-benefits may be sufficiently large to justify cooperation in international negotiations and lead to binding international agreements, of course provided that their existence (and magnitude) is recognized. That is, co-benefits may be a game changer in the political economy of climate change mitigation, if fully internalized in people's beliefs.

Regarding policy drawbacks, all included variables have the expected negative sign, but only loss of purchasing power is significant. Being one of the 67 % of the sample affirming that carbon taxes are an issue for purchasing power is linked with about 15 % lower probability of accepting the instrument. The concern of losing purchasing power makes sense in particular given that at this stage the use of tax revenues is not specified. However, this concern may vanish over time after that the carbon taxes are implemented, since the real effect of loss in consumption on well-being may be lower than actually perceived, as income relative to others may be rather unchanged (Gowdy 2008, see also Howarth 2006).

[5] The coefficient for crowding-out of intrinsic motivation or protest answers does not attain statistical significance. This may suggest that what we face is indeed some motivational crowding-out rather than simply protest, although with no impact on acceptability.

Regressive impacts do not seem to matter in this context. Distributional effects are an issue for an important number of individuals as indicated in the descriptive statistics, but fail to significantly impact acceptability. This result differs from those of most of the literature but provides quantitative evidence for one of the finding from the focus group of Kallbekken and Aasen (2010), which stress that respondents seem to be concerned by distributional effects, but not enough to pretend environmental taxes not to be regressive.

Competitiveness and employment effects are clearly non-significant. We see four possible explanations for their non-significance. First, individuals may not be concerned about competitiveness issues, consumers having different interests than firms, and about unemployment, since they may have very small empathy for potential jobless and perhaps limited fear of how rising levels of unemployment could affect their own situation. However, this may be in contradiction with the evidence based on voting behavior of Thalmann (2004), in which concern about employment issues contributed to the rejection by the Swiss population of three energy tax proposals in spite of an unemployment rate below 2 %. Second, individuals may not expect competitiveness effects to be sufficiently large to become a real problem. This may make sense in the light of the modeling exercise of Sceia et al. (2012), which find very limited terms-of-trade effects for Switzerland when simulating the impact of unilateral moves towards more stringent climate policy. Third, respondents may expect Swiss climate policy to be part of a concerted move undertaken with other countries, e.g. under the umbrella of a renewed Kyoto-like agreement. In such scenario, terms-of-trade effects as modeled by Sceia et al. (2012) become positive. Fourth, the very low concern for employment and competitiveness effects may also be due to the low profile of corporate interest groups at the time of the survey. Indeed, once approaching important votes, the latter tend to employ massive lobbying efforts to have their vested interests internalized by the public, leading the industry flight argument to gain a very important weight in the political discourse (Spash and Lo 2012). This interpretation would call for green lobbying to oppose the industry flight argument and preserve the current outcome (see Dietz et al. 2012).

Altogether, this evidence may question the rationale for the large exemptions and privileges given to some industries by the carbon schemes of some Scandinavian countries or Australia, which have eventually watered down the environmental impact of the tax itself (see Lin and Li 2011; Baranzini and Carattini 2014). Partially rejecting H1, Table 1 suggests that the popularity of carbon taxes may not necessarily imply a trade-off between environmental, distributional and competitiveness effects.

Labeling is not significant at this stage. Regarding the relative performance of the three specifications of Table 1, we see that the goodness-of-fit increases as more variables are added, confirming that policy perception does matter for acceptability, beside individual characteristics.

3.2 Impact of earmarking on carbon tax acceptability

In this section, we focus on the individuals that do not accept the policy proposal in Sect. 3.1 and examine whether their choice changes conditional on the implementation of their preferred option of revenue recycling. The variable to be explained takes value 1 for those changing opinion in favor of the CT/CC and 0 otherwise. We then rely again on a probit model, conditional on choosing 0 in the first acceptability question. We select the least chosen option, tax rebates to households and firms, as the reference case.

The estimation reported in Table 2 includes variables for revenue recycling and labeling, now significant. The literature gives no priors on the potential impact of socioeconomic characteristics on acceptability conditional on the preferred use of tax revenues. We find that in general none is statistically significant, except for a positive effect again of education (p value of 0.098). Policy variables seem instead confirming our set of hypotheses. Trust in the government is associated with a negative sign and a fairly large coefficient. This makes sense in the light of the positive coefficient in Table 1. That is, trust in the government is positively associated with being in favor of the CT/CC regardless of how tax revenues are used, whereas respondents distrusting the government are relatively more likely to reject the first proposal and potentially change opinion in Table 2, once revenues are earmarked. Hence, we can confirm hypothesis H3.

Compared to the rest of respondents, those suggesting that the government should address the issue of energy consumption with taxation do not have a higher probability to change their opinion with earmarking. This is consistent with the result of Table 1 and hypothesis H4. In contrast, those asking the government to better communicate the need and possibilities for energy conservation are, everything else equal, more likely to support the tax both unconditionally and conditionally on earmarking. This may point again to the complementarity between taxation and communication.

The effect of perceived effectiveness is in line with our hypothesis. Expecting the tax to work is linked to a positive effect on acceptability, also among those that rejected the first CT/CC proposal. As suggested by the qualitative analysis of Kallbekken and Aasen (2010), being aware of how the incentive effect works does not necessarily imply no demand for earmarking. The marginal effect in Table 2 is still pretty large and implies that in this sub-sample the likelihood of voting yes once the use of revenue is defined is about 25 % larger for those believing the CT/CC to work than for those that do not. On top of that, there seems to be again a positive effect of co-benefits.

We observe that the probability of reconsidering the CT/CC is larger for those selecting recycling for environmental purposes than for those opting for tax rebates (the dummy of reference), everything else equal. The coefficient for recycling through social cushioning (as defined by the respondent) is not statistically significant. Therefore, it seems that earmarking for environmental purposes really matters for acceptability, confirming hypothesis H2. Since we control for e.g. trust in the government and perceived effectiveness, we relate this demand for environmental recycling with the issue-linkage, i.e. the need for the public to see

Table 2 Carbon tax/climate contribution acceptability with earmarking and revenue recycling: marginal effects at median from probit estimation

Acceptability when earmarking is specified	(1)
Number of cars	0.0753 (0.0652)
Green member	0.0182 (0.192)
Years of education	0.0392* (0.0236)
Gender (male)	0.0695 (0.0956)
Number of adults in the household	0.0208 (0.0447)
Homeowner	−0.0912 (0.121)
Age	0.00183 (0.00373)
Unemployed	0.219 (0.275)
Left	0.213 (0.162)
Right	0.119 (0.131)
Expected cooperation	0.0616 (0.0901)
Trust in the government	−0.341** (0.149)
Government intervention: information	0.157* (0.0925)
Government intervention: taxation	0.130 (0.115)
CT/CC: environmental effectiveness	0.256** (0.0996)
CT/CC: co-benefits	0.0461* (0.0266)
CT/CC: drawbacks (less purchasing power)	0.120 (0.101)
CT/CC: drawbacks (less comfort)	0.0385 (0.0964)
CT/CC: drawbacks (fear of losing job)	−0.437** (0.192)
CT/CC: drawbacks (distributional effects on the poor)	−0.00170 (0.0966)
CT/CC: drawbacks (distributional effects on rural)	−0.123 (0.102)
CT/CC: drawbacks (competitiveness effects)	−0.126 (0.122)
CT/CC: drawbacks (employment effects)	0.201 (0.155)
Revenue recycling: social cushioning	0.0813 (0.129)
Revenue recycling: environmental projects	0.230* (0.126)
Labeling (climate contribution)	0.168* (0.0903)
Pseudo R^2	0.211
Log pseudolikelihood	−82.128
N	152

Robust standard errors in parentheses. * $p<0.1$, ** $p<0.05$, *** $p<0.01$

H_0: all β equal to zero. $\text{Chi}^2(26) = 47.97$, $p = 0.0054$

a straightforward and logical nexus between the tax and the use of revenues (Sælen and Kallbekken 2011). At a given tax rate as in this context, this implies larger abatements, indicating that acceptability tends to go hand in hand with effectiveness (cf. Steg and Vlek 2009).

Hence, this result may contribute to explain why many environmental taxes earmark revenues for environmental purposes, as reported e.g. in the "Database on instruments used for environmental policy" of the Organisation for Economic Co-

operation and Development (OECD). For instance, substantial portions of revenues from local pollution charges are earmarked for environmental improvements in Czech Republic, Estonia, Japan, Poland, Slovak Republic, Turkey and in most Spanish regions, as well as in Quebec. Part or all the revenues from carbon taxes similar to the one proposed in the survey are (or were) used for environmental purposes in several instances, including Quebec's hydrocarbon duty, Boulder's carbon tax (see Hahn 2009) and the former Australian carbon tax. Absent any counterfactual, it is yet not possible to know whether such taxes could have been implemented without earmarking. However, the presence of so many cases of environmental earmarking seems supporting the existence of a worldwide demand for this kind of use of revenues and enhance the general relevance of the political economy argument behind hypothesis H2.

Finally, we observe that labeling has an impact on acceptability, since the coefficient for CC (versus CT) is now significant. The fact that the CC treatment affects acceptability as well as revenue recycling may hint that the term "climate contribution" may not suffice to overcome some general suspicion in the first acceptability question, but it does increase support when earmarking is made explicit. An explanation may be that as introduced by the survey, both the CT and the CC look really like taxes. However, once revenues are earmarked for the environment, the CC may become much more appealing as it really looks as a contribution to the climate, whereas the tax still carries the unfortunate "tax" labeling. While hypothesis H4 is here confirmed, chances of wording to matter may decrease in the political arena, with repeated debates and the intervention of political parties, although based on Swiss data Buetler and Maréchal (2007) call for evidence of a framing effect in voting behavior. In this respect, we note with interest that since 2015 the Swiss government publicly refers to a "climate levy" to replace and widen the scope of its current carbon tax. In doing so, the Swiss government seems to have been inspired by the implementation of the Climate Change Levy in 2001 in the United Kingdom. Again, no counterfactual exists illustrating the popularity of a similar energy tax going under a different name. Yet, based on our findings and similar results in the literature, we can suppose that the decision to name the British scheme of energy taxes "Climate Change Levy" likely did no harm in terms of popularity, and perhaps contributed to its implementation and longevity.

4 Conclusion

Carbon taxes are an effective instrument for curbing greenhouse gas emissions, yet are seldom implemented (Baranzini and Carattini 2014). This paper uses survey data to assess drivers and barriers to public acceptability of carbon taxes. Albeit the political discourse generally focuses on the negative impacts on competitiveness and distributional effects (cf. e.g. Spash and Lo 2012), the data analyzed here indicate that individuals are more concerned by the environmental effectiveness of

the tax. Indeed, we show that perceived environmental effectiveness and expectation of local co-benefits are the main drivers of acceptability. Competitiveness effects are almost completely neglected, whereas distributional issues (in particular regarding poor households) seem to represent a real concern for the general public, but with little impact on acceptability.

According to our findings, communicating both primary and ancillary benefits of carbon taxes seems to be essential for improving acceptability. Along with earmarking, this could be very useful to reduce the opposition related to mistrust in the government and Ramsey-type tax aversion (see Kallbekken et al. 2011). In this respect, we find that in terms of acceptability the best way of recycling the tax revenues is to give the priority to environmental spending. In the same vein, we also provide evidence that using a different label, viz. "climate contribution" rather than "carbon tax", can be beneficial in terms of acceptability.

Therefore, our empirical findings provide evidence that with appropriate design the chances for climate policy tightening could be substantially improved. To the extent that extrapolation from our data is possible, our results would hint that the Swiss population may accept relatively ambitious energy and climate policy of the kind it rejected in 2000, provided that policies are properly conceived and advertised. The evidence that we provide may also guide policymaking in other contexts in which the popularity of policies matter for their chances of implementation. The European experience of environmental taxation and in particular of the (planned) environmental tax reform indicates that a considerable level of popularity is a requirement for implementation in virtually all contexts (see the special issue introduced by Dresner et al. 2006). Transposability of survey estimates to political support and actual voting needs however to take into account the room for hypothetical bias and variation in timing, which is linked to media coverage, lobbying and business-cycle effects.

Acknowledgments The authors thank the Laboratory of Market Studies (LEM) at the Haute Ecole de Gestion de Genève for the valuable support. We are also grateful to two anonymous referees and Jeroen van den Bergh, Richard Howarth, Boris Krey, Emilio Padilla, Jordi Roca, Philippe Thalmann, Frédéric Varone and Frank Vöhringer for excellent comments and helpful discussion. The usual disclaimer applies. Financial support from the Swiss Federal Office of Energy is acknowledged.

Appendix 1: Questionnaires

The original questionnaires were in French. They are available by the authors upon request. As in French and for labeling purposes, we use the term "tax" for the carbon tax of the CT sub-sample. However, it could be called "levy".

A. Energy consumption

1. Do you try to keep your energy consumption under control?

   ☐ Yes, a lot

   ☐ Yes, I do

   ☐ Not really

   ☐ Not at all

2. Do you think that you should consume less energy?
   (multiple answers)

   ☐ Yes, to save money

   ☐ Yes, to help the climate and the environment

   ☐ Yes, if other people do it too

   ☐ Yes, if other countries do it too

   ☐ No, I see no reasons to consume less energy

   ☐ No, I do my best already

3. How much (in %) should the price of the following energy carriers increase to lead you to consume 10% less of it?

   Gasoline: _

   Electricity: _

   Heating fuel: _

4. Do you expect other people in Switzerland to be willing to reduce their energy consumption?

   ☐ Yes

   ☐ No

   ☐ I do not know

5. Do you expect other countries to be willing to reduce their energy consumption?

   ☐ Yes

   ☐ No

   ☐ I do not know

6. In your opinion, should the Swiss government intervene to stimulate energy conservation?

   ☐ Yes, by providing information and raising awareness

   ☐ Yes, by subsidizing public transportation

   ☐ Yes, by taxing CO_2 emissions

   ☐ No, this is beyond its scope

   ☐ I do not care of energy conservation

   ☐ I do not know

7. In your opinion, in the next 10 years, the following energy prices will:

Gasoline	Increase of _ (%)	Stay constant	Decrease of _ (%)
Electricity	Increase of _ (%)	Stay constant	Decrease of _ (%)
Heating fuel	Increase of _ (%)	Stay constant	Decrease of _ (%)

8. Which of the following factors do you expect to lead to an increase in energy prices?

	Yes	No	Do not know
Climate policy tightening	☐	☐	☐
Scarcity	☐	☐	☐
Nuclear exit	☐	☐	☐
Expensive renewable energy	☐	☐	☐
Other (please specify)	☐	☐	☐

9. In your opinion, what policy may be needed to cope with higher energy prices? (multiple answers)

- ☐ Improved communication (e.g. saving tips)
- ☐ Subsidies for all households
- ☐ Subsidies for low-income households
- ☐ Subsidies for rural households
- ☐ Tax rebates for all households
- ☐ Tax rebates for low-income households
- ☐ Tax rebates for rural households
- ☐ Investments in public transportation
- ☐ None of these
- ☐ Other (please specify)

B Carbon tax/Climate contribution

We are now going to ask you a series of questions on a CO_2 tax/climate contribution. This tax/contribution engenders an increase in the price of energy from fossil sources. Imagine a CO_2 tax/climate contribution of 120 CHF/tCO_2 on all fossil fuels, which would imply an increase in the price of gasoline and heating fuels of about 30 cents/liter (more or less 15% of current gasoline price and 30% of current heating oil price).

10. Would this CO_2 tax/climate contribution modify your energy conservation efforts?

- ☐ Less efforts
- ☐ No change
- ☐ More efforts

11. Do you think that this CO_2 tax/climate contribution would allow for a reduction in the amount of energy consumed by the Swiss population?

- ☐ Yes
- ☐ No
- ☐ I do not know

12. What are in our opinion the benefits of a CO_2 tax/climate contribution?
(do not show the answers to respondents, see what they mention spontaneously; multiple answers)

	For you	For the society
Lower CO_2 emissions	☐	☐
Better air quality	☐	☐
Less road congestion	☐	☐
Better health	☐	☐
Less road accidents	☐	☐
None	☐	☐
Other (please specify)	☐	☐

13. What are the drawbacks of this CO_2 tax/climate contribution for your household? (multiple answers)

☐ Loss of purchasing power
☐ Loss of comfort
☐ Fear of losing job
☐ No drawbacks
☐ Other (please specify)

14. What are the drawbacks of this CO_2 tax/climate contribution for the Swiss society?

☐ Loss of purchasing power
☐ Loss of competitiveness
☐ Detrimental effects on low-income households
☐ Higher inequalities between urban and rural areas
☐ No drawbacks
☐ Other (please specify)

15. In spite of drawbacks, is the implementation of such tax/contribution acceptable?

☐ Yes
☐ No
☐ I do not know

16. In your opinion, should the government offset the detrimental effects of such CO_2 tax/climate contribution on the following groups?

	Yes	No
Low-income households (<50'000 CHF gross/year)	☐	☐
Middle-income households (50'000-100'000 CHF gross/year)	☐	☐
High-income households (>100'000 CHF gross/year)	☐	☐
Rural households	☐	☐
Urban households	☐	☐
Large families	☐	☐
Elderly people	☐	☐
Firms	☐	☐

17. Please rank in a decreasing order of preference the following ways to use the revenues from the CO_2 tax/climate contribution.

☐ Social cushioning in favor of most affected households

☐ Tax rebates for households and firms

☐ Funding environmental projects, including subsidies to renewable energy

☐ Other (please specify)

18. If the revenues from the CO_2 tax/climate contribution were to be used as you indicate in the questions 16 and 17, would you accept this CO_2 tax/climate contribution?

☐ Yes

☐ No

☐ I do not know

19. If in 6 months from now you were asked to vote on a CO_2 tax/climate contribution, what is the price increase in fossil fuels that you would be willing to accept?

☐ 0%
☐ 0-5%
☐ 5-10%
☐ 10-15%
☐ 15-20%
☐ 20-25%
☐ 25-30%
☐ 30%

20. Does it exist in Switzerland a CO_2 tax on heating fuels?

☐ Yes
☐ No
☐ I do not know

C. General information

21. You are:

☐ Female
☐ Male

22. Birth year:

23. Postcode:

24. How many people are in your household (including the respondent)?

Number of adults:

Number of children (less than 18 years):

25. Currently you are:

☐ Homeowner
☐ Renter

26. How many cars does your household own?

☐ 0
☐ 1
☐ 2
☐ 3
☐ 4 or more

27. Are you member of one or more environmental organizations?

☐ Yes
☐ No

28. In your opinion, protecting the environment is a:

☐ Urgent matter
☐ Important matter, but not a priority
☐ Not urgent at all

29. What is your degree of trust in the Swiss government?

☐ Not confident at all
☐ Rather not confident
☐ Rather confident
☐ Completely confident

30. Your current professional status is:

☐ Homemaker
☐ Student
☐ Employee
☐ Manager
☐ Senior manager
☐ Self-employed
☐ Retired
☐ Jobless
☐ Other (please specify)

31. What level of education did you reach? If you are currently studying, please select the level of education corresponding to the highest diploma you already hold.

☐ Compulsory schooling
☐ Apprenticeship
☐ College
☐ Professional education
☐ University of applied sciences
☐ University

32. How would you locate yourself on the left-right axis?

☐ Left
☐ Center
☐ Right
☐ No answer

33. What is your household's yearly gross income?

☐ <25'000 CHF
☐ 25'000-50'000 CHF
☐ 50'000-75'000 CHF
☐ 100'000-125'000 CHF
☐ 125'000-150'000 CHF
☐ >150'000 CHF
☐ No answer

Appendix 2: Tables

See Tables 3, 4 and 5.

Table 3 Socioeconomic characteristics: sample's summary statistics

Variable	Mean	Std. dev.	Min.	Max.	*N*
Gender (male)	0.521	0.5	0	1	336
Age	36.860	14.04	19	85	336
Years of education	15.782	1.935	11	18	330
Categories of income	4.029	1.816	1	7	239
Labor market (active)	0.949	0.221	0	1	332
Number of adults in the household	2.306	1.194	0	6	337
Number of kids in the household	0.333	0.681	0	4	291
Homeowner	0.223	0.417	0	1	336
Number of cars	1.279	0.957	0	4	337

Table 4 Environmental attitudes and behavior: summary statistics

Variable	Mean	*N*
Energy consumption: very attentive	0.2	337
Energy consumption: attentive	0.53	337
Energy consumption: not very attentive	0.22	337
Energy consumption: not attentive at all	0.05	337
Saving energy: to save money	0.77	338
Saving energy: for the environment	0.59	338
Saving energy: other people	0.06	338
Saving energy: other countries	0.06	338
Saving energy: no reasons	0.06	338
Saving energy: the best already	0.07	338
Elastic: gasoline	23.40	292
Elastic: electricity	27.68	297
Elastic: heating fuels	24.59	288
Expected cooperation	0.76	242
Expected foreign cooperation	0.52	247
Government intervention: information	0.73	337
Government intervention: public transportation	0.61	338
Government intervention: taxation	0.35	338
Government intervention: unnecessary	0.03	338
Government intervention: irrelevant	0.02	337
Future prices: gasoline	27	331
Future prices: electricity	16	334
Future prices: heating fuels	18	335
Drivers: climate policy	0.58	337
Drivers: scarcity	0.89	337
Drivers: nuclear exit	0.5	337
Drivers: renewables	0.53	337
Accompanying: awareness	0.63	338
Accompanying: subsidies for all	0.18	338
Accompanying: subsidies for poor	0.25	338
Accompanying: subsidies for rural	0.1	338
Accompanying: rebates for all	0.25	338
Accompanying: rebates for poor	0.25	338
Accompanying: rebates for rural	0.07	338
Accompanying: public transportation	0.62	338

Table 5 Policy perceptions and acceptability: summary statistics

Variable	Mean	*N*
Effect on own behavior: less consumption	0.56	338
Effect on own behavior: no change	0.37	338
Effect on own behavior: more consumption	0.07	338
Environmental effectiveness	0.48	338
Co-benefit: better air quality (respondent and society)	0.56	320
Co-benefit: less road congestion (respondent and society)	0.27	320
Co-benefit: better health (respondent and society)	0.42	320
Co-benefit: less road accidents (respondent and society)	0.18	320
Drawback: less purchasing power	0.67	338
Drawback: less comfort	0.34	338
Drawback: fear of losing job	0.05	338
Drawback: none	0.22	338
Drawback: less purchasing power (society)	0.69	338
Drawback: loss of competitiveness	0.20	338
Drawback: distributional effects on the poor	0.46	338
Drawback: rise in unemployment	0.11	338
Acceptability	0.49	338
Social cushioning: low income	0.72	333
Social cushioning: middle income	0.48	333
Social cushioning: high income	0.14	333
Social cushioning: rural	0.35	333
Social cushioning: urban	0.19	333
Social cushioning: large families	0.49	333
Social cushioning: elderly people	0.58	333
Social cushioning: firms	0.24	333
Revenue recycling: social cushioning (first)	0.26	313
Revenue recycling: tax rebates (first)	0.11	313
Revenue recycling: environmental projects (first)	0.60	313
Acceptability when earmarking is specified	0.64	337
Tax rate: 0 %	0.13	330
Tax rate: 0–5 %	0.30	330
Tax rate: 5–10 %	0.31	330
Tax rate: 10–15 %	0.16	330
Tax rate: 15–20 %	0.05	330
Tax rate: 20–25 %	0.02	330
Tax rate: 25–30 %	0.02	330

References

Achtnicht M (2012) German car buyers' willingness to pay to reduce CO_2 emissions. Clim Change 113(3–4):679–697

Baranzini A, Carattini S (2014) Taxation of emissions of greenhouse gases. In: Freedman B (ed) Global environmental change, Number 1 in Handbook of Global Environmental Pollution. Springer, Netherlands, pp 543–560

Baranzini A, Goldemberg J, Speck S (2000) A future for carbon taxes. Ecol Econ 32(3):395–412

Baranzini A, Thalmann P, Gonseth C (2004) Swiss climate policy: Combining VAs with other instruments under the menace of a CO_2 tax. In: Baranzini A, Thalmann P (eds) Voluntary approaches in climate policy

Baranzini A, Weber S, Bareit M, Mathys NA (2013) The causal relationship between energy use and economic growth in Switzerland. Energy Econ 36:464–470

Baumol WJ, Oates WE (1971) The use of standards and prices for protection of the environment. Swed J Econ 73(1):42–54

Bazin D, Ballet J, Touahri D (2004) Environmental responsibility versus taxation. Ecol Econ 49(2):129–134

Becker GS, Murphy KM (1993) A simple theory of advertising as a good or bad. Q J Econ 108(4):941–964

Bolsen T, Leeper TJ, Shapiro MA (2014) Doing what others do norms, science, and collective action on global warming. Am Polit Res 42(1):65–89

Bornstein N, Lanz B (2008) Voting on the environment: price or ideology? Evidence from Swiss referendums. Ecol Econ 67(3):430–440

Bornstein N, Thalmann P (2008) 'I pay enough taxes already!' Applying economic voting models to environmental referendums. Soc Sci Q 89(5):1336–1355

Brännlund R, Ghalwash T (2008) The income-pollution relationship and the role of income distribution: an analysis of Swedish household data. Resour Energy Econ 30(3):369–387

Brannlund R, Persson L (2012) To tax, or not to tax: preferences for climate policy attributes. Clim Policy 12(6):704–721

Bristow AL, Wardman M, Zanni AM, Chintakayala PK (2010) Public acceptability of personal carbon trading and carbon tax. Ecol Econ 69(9):1824–1837

Brouwer R, Brander L, Beukering PV (2008) "A convenient truth": air travel passengers' willingness to pay to offset their CO_2 emissions. Clim Change 90(3):299–313

Bruvoll A, Larsen BM (2004) Greenhouse gas emissions in Norway: do carbon taxes work? Energy Policy 32(4):493–505

Buetler M, Maréchal MA (2007) Framing effects in political decision making: evidence from a natural voting experiment. CESifo Working Paper Series 1940, CESifo Group Munich

Carattini S (2015). Green consumers and climate policy: reconciling Ostrom and Nyborg, Howarth and Brekke. SSRN Scholarly Paper ID 2671328, Social Science Research Network

Carattini S, Baranzini A, Roca J (2015) Unconventional determinants of greenhouse gas emissions: the role of trust. Environ Policy Gov 25(4):243–257

Cherry TL, Kallbekken S, Kroll S (2012) The acceptability of efficiency-enhancing environmental taxes, subsidies and regulation: an experimental investigation. Environ Sci Policy 16:90–96

Cohen MA, Viscusi WK (2012) The role of information disclosure in climate mitigation policy. Clim Change Econ 03(04)

Deacon RT, Shapiro P (1975) Private preference for collective goods revealed through voting on referenda. Am Econ Rev 65(5):943–955

Deci EL, Ryan RM (1985) Intrinsic motivation and self-determination in human behavior. Springer, Berlin

Diederich J, Goeschl T (2013) Willingness to pay for voluntary climate action and its determinants: field-experimental evidence. Environmental and Resource Economics, pp 1–25

Dietz S, Marchiori C, Tavoni A (2012) Domestic politics and the formation of international environmental agreements. Working Paper 100, Centre for Climate Change Economics and Policy

Dresner S, Dunne L, Clinch P, Beuermann C (2006) Social and political responses to ecological tax reform in Europe: an introduction to the special issue. Energy Policy 34(8):895–904

Godal O, Holtsmark B (2001) Greenhouse gas taxation and the distribution of costs and benefits: the case of Norway. Energy Policy 29(8):653–662

Goeschl T, Perino G (2012) Instrument choice and motivation: evidence from a climate change experiment. Environ Resour Econ 52(2):195–212
Gowdy JM (2008) Behavioral economics and climate change policy. J Econ Behav Organ 68(3–4):632–644
Greene WH (2011) Econometric analysis. Prentice Hall, New Jersey
Hahn RW (2009) Greenhouse gas auctions and taxes: some political economy considerations. Rev Environ Econ Policy 3(2):167–188
Howarth RB (2006) Optimal environmental taxes under relative consumption effects. Ecol Econ 58(1):209–219
IPCC (2014) Fifth assessment report—mitigation of climate change. Technical report
Kahneman D, Tversky A (2000) Choices, values, and frames. Cambridge University Press, Cambridge
Kallbekken S, Aasen M (2010) The demand for earmarking: results from a focus group study. Ecol Econ 69(11):2183–2190
Kallbekken S, Kroll S, Cherry TL (2011) Do you not like Pigou, or do you not understand him? Tax aversion and revenue recycling in the lab. J Environ Econ Manag 62(1):53–64
Kallbekken S, Sælen H (2011) Public acceptance for environmental taxes: self-interest, environmental and distributional concerns. Energy Policy 39(5):2966–2973
Lin B, Li X (2011) The effect of carbon tax on per capita CO_2 emissions. Energy Policy 39(9):5137–5146
Lindman A, Ek K, Söderholm P (2013) Voluntary citizen participation in carbon allowance markets: the role of norm-based motivation. Clim Policy 13(6):680–697
Loeschel A, Sturm B, Vogt C (2013) The demand for climate protection—empirical evidence from Germany. Econ Lett 118(3):415–418
Longo A, Hoyos D, Markandya A (2012) Willingness to pay for ancillary benefits of climate change mitigation. Environ Resour Econ 51(1):119–140
Mathys NA, de Melo J (2011) Political economy aspects of climate change mitigation efforts. World Econ 34(11):1938–1954
Metcalf GE (2009) Designing a carbon tax to reduce U.S. greenhouse gas emissions. Rev Environ Econ Policy 3(1):63–83
Nyborg K, Howarth RB, Brekke KA (2006) Green consumers and public policy: on socially contingent moral motivation. Resour Energy Econ 28(4):351–366
OECD (2014) The cost of air pollution health impacts of road transport: health impacts of road transport. OECD Publishing
Ostrom E (2009) A polycentric approach for coping with climate change. Policy Research Working Paper Series, The World Bank
Owen AL, Videras J (2008) Trust, cooperation, and implementation of sustainability programs: the case of Local Agenda 21. Ecol Econ 68(1–2):259–272. doi:10.1016/j.ecolecon.2008.03.006
Pezzey JCV, Jotzo F (2013) Carbon tax needs thresholds to reach its full potential. Nat Clim Change 3(12):1008–1011
Pittel K, Rübbelke DTG (2008) Climate policy and ancillary benefits: a survey and integration into the modelling of international negotiations on climate change. Ecol Econ 68(1–2):210–220
Roca J (2003) Do individual preferences explain the environmental Kuznets curve? Ecol Econ 45(1):3–10
Roca J, Serrano M (2007) Income growth and atmospheric pollution in Spain: an input–output approach. Ecol Econ 63(1):230–242
Roe B, Teisl MF, Levy A, Russell M (2001) US consumers' willingness to pay for green electricity. Energy Policy 29(11):917–925
Sælen H, Kallbekken S (2011) A choice experiment on fuel taxation and earmarking in Norway. Ecol Econ 70(11):2181–2190
Sceia A, Altamirano-Cabrera J-C, Vielle M, Weidmann N (2012) Assessment of acceptable Swiss post-2012 climate policies. Swiss J Econ Stat (SJES) 148(II):347–380
Sciarini P, Bornstein N, Lanz B (2007) The determinants of voting choices on environmental issues: a two-level analysis. In: de Vreese, C.H. (ed.) The dynamics of referendum campaigns. An international perspective. Palgrave Macmillan, pp 234–266
Spash CL, Lo AY (2012) Australia's carbon tax: a sheep in wolf's clothing? Econ Labour Relat Rev 23(1):67–85
Stadelmann-Steffen I (2011) Citizens as veto players: climate change policy and the constraints of direct democracy. Environ Polit 20(4):485–507
Steg L, Dreijerink L, Abrahamse W (2006) Why are energy policies acceptable and effective? Environ Behav 38(1):92–111

Steg L, Vlek C (2009) Encouraging pro-environmental behaviour: an integrative review and research agenda. J Environ Psychol 29(3):309–317

Sterner T (ed) (2011) Fuel taxes and the poor: the distributional effects of gasoline taxation and their implications for climate policy. RFF Press

Thalmann P (2004) The public acceptance of green taxes: 2 million voters express their opinion. Public Choice 119:179–217

UNEP (2013) The emissions gap report 2013—a UNEP synthesis report

Zhang ZX, Baranzini A (2004) What do we know about carbon taxes? An inquiry into their impacts on competitiveness and distribution of income. Energy Policy 32(4):507–518

Annex 5

Centre for Climate Change Economics and Policy

An ESRC Research Centre

Grantham Research Institute on Climate Change and the Environment

Green taxes in a post-Paris world:

are millions of nays inevitable?

Stefano Carattini, Andrea Baranzini, Philippe Thalmann, Frédéric Varone and Frank Vöhringer

June 2016

Centre for Climate Change Economics and Policy
Working Paper No. 273

Grantham Research Institute on Climate Change and the Environment
Working Paper No. 243

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

The Grantham Foundation for the Protection of the Environment

UNIVERSITY OF LEEDS

LSE The London School of Economics and Political Science

The Centre for Climate Change Economics and Policy (CCCEP) was established by the University of Leeds and the London School of Economics and Political Science in 2008 to advance public and private action on climate change through innovative, rigorous research. The Centre is funded by the UK Economic and Social Research Council. Its second phase started in 2013 and there are five integrated research themes:

1. Understanding green growth and climate-compatible development
2. Advancing climate finance and investment
3. Evaluating the performance of climate policies
4. Managing climate risks and uncertainties and strengthening climate services
5. Enabling rapid transitions in mitigation and adaptation

More information about the Centre for Climate Change Economics and Policy can be found at: http://www.cccep.ac.uk.

The Grantham Research Institute on Climate Change and the Environment was established by the London School of Economics and Political Science in 2008 to bring together international expertise on economics, finance, geography, the environment, international development and political economy to create a world-leading centre for policy-relevant research and training. The Institute is funded by the Grantham Foundation for the Protection of the Environment and the Global Green Growth Institute. It has nine research programmes:

1. Adaptation and development
2. Carbon trading and finance
3. Ecosystems, resources and the natural environment
4. Energy, technology and trade
5. Future generations and social justice
6. Growth and the economy
7. International environmental negotiations
8. Modelling and decision making
9. Private sector adaptation, risk and insurance

More information about the Grantham Research Institute on Climate Change and the Environment can be found at: http://www.lse.ac.uk/grantham.

Green taxes in a post-Paris world: are millions of nays inevitable?

Stefano Carattini[*,†,‡], Andrea Baranzini[†], Philippe Thalmann[§], Frédéric Varone[¶] and Frank Vöhringer[§]

June 15, 2016

Abstract

Turning greenhouse gas emissions pledges into domestic policies is the next challenge for governments. We address the question of the acceptability of cost-effective climate policy in a real-voting setting. First, we analyze voting behavior in a large ballot on energy taxes, rejected in Switzerland in 2015 by more than 2 million people. Energy taxes were aimed at completely replacing the current value-added tax. We examine the determinants of voting and find that distributional and competitiveness concerns reduced the acceptability of energy taxes, along with the perception of ineffectiveness. Most people would have preferred tax revenues to be allocated for environmental purposes. Second, at the same time of the ballot, we tested the acceptability of alternative designs of a carbon tax with a choice experiment survey on a representative sample of the Swiss population. Survey respondents are informed about environmental, distributional and competitiveness effects of each carbon tax design. These impacts are estimated with a computable general equilibrium model. This original setting generates a series of novel results. Providing information on the expected environmental effectiveness of carbon taxes reduces the demand for environmental earmarking. Making distributional effects salient generates an important demand for progressive designs, e.g. social cushioning or recycling via lump-sum transfers. The case of lump-sum recycling is particularly striking: it is sufficient to show its desirable distributional properties to make it one of the most preferred designs, which corresponds to a completely novel result in the literature. We show that providing proper information on the functioning of environmental taxes can close both the gap between acceptability *ex ante* and *ex post* and the gap between economists' prescriptions and the preferences of the general public.

Keywords: Carbon taxes; Acceptability; Political economy; Ballot data; Choice experiment
JEL Codes: D72; D78; H23; Q54

---

[*]Corresponding author: s.carattini@lse.ac.uk. The authors thank Sam Fankhauser and Boris Krey for valuable remarks on a previous version of this paper. The usual disclaimer applies. All authors acknowledge financial support from the Swiss Federal Office of Energy. Carattini acknowledges support from COST Action IS1309 "Innovations in Climate Governance: Sources, Patterns and Effects" (INOGOV).

[†]Haute école de gestion de Genève, HES-SO // University of Applied Sciences Western Switzerland

[‡]Grantham Research Institute on Climate Change and the Environment and ESRC Centre for Climate Change Economics and Policy, London School of Economics and Political Science

[§]Swiss Federal Institute of Technology Lausanne - Ecole Polytechnique Federale de Lausanne (EPFL)

[¶]Department of Political Science and International Relations, University of Geneva

1 Introduction

During the last decades, countries and international organizations have struggled to define a system of global governance able to tackle climate change. The Kyoto Protocol spurred the adoption of a first generation of climate policies (Fankhauser et al. 2015), but much more effort is required to meet the challenge of climate change mitigation (IPCC 2014). Unilateral policies have emerged to partly compensate for the continued failure of international negotiations (Ostrom 2009; Jordan et al. 2015), but only a fraction of countries opted for energy and carbon taxes (Baranzini and Carattini 2014; World Bank 2014). Most countries went for "soft policies" such as subsidies for renewable energies, which in some cases turned up to be not only strongly regressive but also extremely expensive (Marcantonini and Ellerman 2014). Vested interests and the general unpopularity of taxes are the main reasons behind this political choice.

The developments related with the 2015 Conference of Parties to the United Nations Framework Convention on Climate Change and the Paris Agreement have created a major breakthrough in the international negotiations for climate change mitigation. However, countries' emissions pledges are not credible policy commitments. The world is at a turning point: strong domestic policies are now necessary to meet the Paris pledges at a reasonable cost. Any other outcome is likely to put the pledge-and-review system under pressure and to jeopardize the future tightening of current pledges (Baranzini et al. 2015).

How to overcome resistance to energy and carbon taxes is thus of primary interest. A recent literature has attempted to provide a first set of explanations to the lack of public support for environmental taxes. Since real ballots on environmental taxes take place sporadically and so real voting behavior is hard to observe, most of the literature relies on survey techniques to approximate the determinants of voting behavior. These surveys are usually realized in neutral times, i.e. absent any political campaigning. However, vested interests and media coverage are very powerful drivers of public opinion on environmental matters (Sampei and Aoyagi-Usui 2009; Jacobsen 2011; Spash and Lo 2012).

On March 8, 2015 the Swiss population was called to vote on a popular initiative aiming at replacing the current value-added tax (VAT) with an energy tax. About 2.2 million voters expressed their opinion. The proposal was rejected by a large majority, 92% of voters. Right after the ballot, we collected data on a representative sample of the Swiss population, to explain the observed voting behavior. This strategy is used to decrease the likelihood of socially-approved answers and also allows us to compare our sample with the observed outcome.

At the same time, we administered a choice experiment to another representative sample of the Swiss population, taking advantage from the very specific timing to assess the acceptability of alternative tax designs in presence of high political salience. In the choice-experiment setting we consider a carbon tax with four different tax rates and five revenue recycling options: income tax rebates, reduction of the value-added tax, lump-sum transfers, social cushioning and earmarking for additional emission abatements through the purchase of foreign offsets. We exploit the results of a general equilibrium modeling exercise to inform respondents on the expected outcomes of each tax design in terms of energy price increases, emission abatements, overall economic effects and distributional impacts. In this way, we address some of the most recurrent obstacles to the popularity of carbon taxes, all of which are arguably driven by imperfect information: excessive fear of adverse competitiveness and distributional effects, perceived ineffectiveness and misunderstanding of revenue neutrality. To the best of our knowledge, this is the first time such methodological approach is used. In the choice experiment, respondents face three alternatives: two different carbon tax designs, and the status quo. Hence, we reproduce the situation of real ballots, in which voters are asked to express their opinion on different proposals, with of course the possibility to reject all of them (see Kriesi 2005).

Our study is of interest for all democratic settings, with or without a system of direct democracy. We use Switzerland as a laboratory of study, but the divergence between economists and the general public on the benefits of revenue-neutral environmental taxes is a recurring problem to environmental tax reforms all around Europe (Dresner et al. 2006). The unpopularity of carbon taxes has hampered their implementation in France (Deroubaix and Lévèque 2006), while fear of competitiveness effects led to massive exemptions in Scandinavian countries, decreasing the potential for any sizeable environmental effect (Baranzini and Carattini 2014). Similar obstacles reduce the popularity of carbon taxes in emerging economies, too (Gevrek and Uyduranoglu 2015).

We find that the design of green taxes is the main driver of acceptability, and that information provision can lead to very different results from those in the literature. Data on voting behavior shows that the chances of the 2015 popular initiative would have been much higher if tax revenues had been earmarked for environmental purposes rather than for replacing the VAT, everything else equal. Concerns about the effect of higher energy prices on the distribution of income as well as on the competitiveness of firms are among the main determinants of rejection. People are also generally skeptics about the potential change in behavior that energy taxes could generate.

The design of our choice experiment addresses all these concerns and provides a series of original findings. Estimations from our modeling scenarios suggest that all carbon tax designs under investigation imply limited competitiveness effects and all provide significant reduction in emissions. Using the full tax revenue to purchase foreign offsets allow for massive emission abatements, in the domain of negative emissions. Most recycling options imply slightly regressive effects, except for lump-sum transfers and social cushioning, which (the latter by design) lead to a net progressive effect.

A common finding in the literature is that people are most willing to accept a carbon tax if its revenues are used to strengthen its environmental effectiveness, which people believe to be small. This stylized fact is confirmed by our analysis of voting behavior. However, our choice-experimental setting, by informing on the emissions reduction associated with the different carbon taxes, allows closing the gap between (possibly low) perceived effectiveness and (higher) predicted effectiveness. As a result, we find that earmarking for additional abatements is no longer particularly attractive. Information on the scenarios' predictions renders instead lump-sum transfers and social cushioning particularly popular, by making salient their progressive properties. The finding for lump-sum transfers is particularly striking. Despite their minimal administrative burden and the ability to address distributional concerns (Baranzini et al. 2000; Metcalf 2009), lump-sum transfers are especially neglected by the literature on the acceptability of carbon taxes. The reason for this is that these properties may not to be perceived by the population, along with revenue neutrality. Our setting shows however that it is sufficient to provide people with some supplementary information to reduce the gap between their preferences and economists' prescriptions.

We find that recycling through income tax rebates is relatively unpopular, as often found in the literature. People do not seem to understand the concept of environmental tax reform, or at least they do not see its advantages as some economists do. We stress that our modeling scenarios do not suggest the existence of a particular double dividend, i.e. positive economic effects through the reduction of distortionary taxes. Reductions in the value-added tax perform similarly poorly, in terms of acceptability. We also find that the support for green taxes decreases linearly with the rise in the tax rate. If we simulate based on our choice experiment the level of acceptability of the popular initiative voted on March 8 2015, we obtain a figure that is very consistent with the observed real outcome, indicating a high external validity of the results based on our choice experiment.

We contribute to the literature on the acceptability of carbon taxes by shed-

ding new light on the obstacles to the acceptability of carbon taxes. We make the voting decision in the choice-experimental setting as realistic as possible and provide people with sufficient details to take an informed decision on carbon taxes. Our results show that making the effect of environmental taxes salient can contribute to render relatively unpopular designs much more popular. So far, the literature has showed that only experiencing the functioning of a given policy allows citizens to revise their beliefs on the effectiveness and fairness of environmental taxes, which by default tend to be overly pessimistic (cf. e.g. Carattini et al. 2016). Our approach thus provides an alternative to the use of trials that has been increasingly called for to remedy environmental taxes' lack of popularity (Sælen and Kallbekken 2011; Cherry et al. 2014; Carattini et al. 2016). With the proper design and information, acceptable carbon taxes can exist at a moderately high tax rate, and sustain credible climate policies.

2 Context

2.1 Literature review

The theoretical literature on the political economy of environmental policy mostly focuses on lobbying by energy-intensive industries (see Oates and Portney 2003 for a review). Yet, Kirchgassner and Schneider (2003) stress the importance of considering voters' preferences, and how their pure economic objectives may compete with other interests, including environmental preferences. The opinion of the general public may however be biased by media and captured by vested interests, possibly leading to inaccurate opinion formation and policy-making (Millner and Ollivier 2015). But citizens can also organize in environmental advocacy groups and play an active role in the political arena. The model of Dietz et al. (2012) shows that the presence of green lobbies influencing policymakers may contribute to increase the stringency of environmental policy, as well as the likelihood of a stable coalition in environmental agreements.

The theoretical literature usually takes a narrow perspective and presumes that people rarely vote on policies, but rather for candidates and parties. The empirical literature has instead taken a broader perspective, assessing for instance the private willingness to pay for climate change mitigation (see Nemet and Johnson 2010 for a review), as well as the acceptability of specific policies. The case of environmental taxes has received particular attention. So popular among economists for reasons of efficiency and environmental effectiveness (Baranzini et al. 2015) and so unpopular among the general public,

they represent a unique opportunity to study the consequences of informational asymmetries between citizens, policy-makers and experts.

Empirical economists have used a wide range of tools to understand the determinants of energy taxes' acceptability. Qualitative assessments using focus groups have helped understanding the obstacles to the European Environmental Tax Reform (Dresner et al. 2006) and to environmental taxes more in general (Kallbekken and Aasen 2010). Qualitative surveys have also been used to orient quantitative surveys, as in Baranzini and Carattini (2016).

The focus groups of Dresner et al. (2006) revealed the high level of distrust in environmental tax reforms among the general public. The general public seems to underestimate the effectiveness of environmental taxes and to perceive them mainly as a pretext for raising additional public revenues. People may only be willing to support their introduction if revenues are clearly earmarked for environmental purposes. They also wonder how environmental taxes could green the economy if revenues were to be redistributed. Moreover, they raise fears of adverse competitiveness and distributional effects.

These findings from small samples have been then confirmed by larger surveys. Steg et al. (2006) interview about one hundred respondents in the Netherlands about the perceived effectiveness and acceptability of energy subsidies and taxes. They find subsidies to be much more effective, at least in people's eyes. "Pull measures" (i.e. subsidies) are seen as incentives driving a voluntary change in behavior, whereas taxes are felt as coercive measures imposing a change in behavior and facing people's resistance. Taxes can however be perceived as effective if revenues are earmarked for environmental purposes. In terms of acceptability, instruments and designs that are perceived as effective (i.e. subsidies) overperform those that are not (i.e. taxes). Similar results are provided in Kallbekken and Sælen (2011) based on a Norwegian sample. In their sample, perceived ineffectiveness of fuel taxes represents a major obstacle to acceptability, as in the study on the popularity of carbon taxes of Baranzini and Carattini (2016). In this respect, the latter find that acceptability depends on the expectation of both primary and ancillary benefits. Earmarking revenues for environmental purposes contributes to reduce the hostility to carbon tax, as well as renaming it "climate contribution".

The potential of standard surveys is however limited, in particular when respondents are required to deal with complex issues such as the design of carbon taxes. A few authors have thus opted for choice experiments, which also allow focusing on the internal validity and thus reduce the room for bias related to hypothetical answers. Bristow et al. (2010) analyze the acceptability of personal

carbon trading schemes and carbon taxes with a sample of about 300 individuals. They compare different tax rates and modes of recycling and find for instance that tax thresholds perform particularly well in terms of acceptability. Thresholds can indeed reduce the regressive effects of carbon taxes, similarly to lump-sum recycling. While the authors call for the use of larger samples to support their findings, they suggest that acceptable carbon tax designs are not a chimaera. Sælen and Kallbekken (2011) show, with a choice experiment, that the chances for carbon taxes to be acceptable are higher with earmarking for environmental revenues. With this type of recycling, the Norwegian population would agree to an increase of the current fuel tax rate by about 15%. Brannlund and Persson (2012) also test different designs for a carbon tax with a choice experiment. The labeling of the tax changes randomly with the other attributes and the authors find that even labeling it "other" is better than using its real name, "tax". Progressive designs are also preferred to regressive ones. Gevrek and Uyduranoglu (2015) extend the analysis of the acceptability of carbon taxes to emerging economies with a choice experiment for Turkey. While their setting does not allow measuring the overall level of acceptability of Turkish carbon taxes, their empirical exercise provides very similar findings to the literature in developed countries, including the preference for progressive schemes, for earmarking of revenues and for low tax rates.

Choice experiments contribute to tackle the issue of hypothetical bias. However, inference is still based on stated preferences. Revealed preferences are elicited in lab experiments, but issues of external validity may arise if the general public behaves differently than the sample participating in the experiment (Harrison and List 2004). Some examples of lab experiments are available in this literature. For instance, Kallbekken et al. (2011) provide experimental evidence in favor of tax aversion and of the demand for earmarking of Pigouvian tax revenues. They show that efficiency and acceptability may conflict even when real stakes are involved, i.e. participants do not necessarily prefer the policy that is pay-off maximizing. Labeling carbon taxes as "fee" helps however to reduce tax aversion. The experiment of Cherry et al. (2012) supports these findings, as well as the analysis of Steg et al. (2006), showing that "non-coercive" instruments such as subsidies (and even quotas) are much preferred to carbon taxes, so that policymakers betting on carbon taxes may end up with the status quo. In the authors' words, inefficient "half measures" are more likely to be politically feasible than efficient "full measures".

These methods are used as imperfect substitutes for the observation of real ballots on environmental taxes, which are unthinkable in some countries and very

rare in others. A few opportunities to study voting behavior on environmental matters already occurred in the United States or Switzerland (see Deacon and Shapiro 1975; Fischel 1979; Kahn and Matsusaka 1997; Fort and Bunn 1998; Salka 2001; Kahn 2002; Stadelmann-Steffen 2011), even though not exclusively on environmental taxes. An exception is Thalmann (2004), who analyzes three energy tax proposals voted and rejected by the Swiss population in 2000. While all proposals failed, two were really close to the majority threshold. Differences in the use of revenues (earmarking for subsidizing renewable energy versus redistribution) and in the tax rates are shown to potentially contribute to the small differences in the rate of approval between the revenue-neutral "Green tax reform" (44.6% of yes-votes) and the "Energy conservation package" (46.6%). The third alternative, the "Solar initiative" (31.9%), proposed to earmark half of the revenues for solar energy, and the other half for energy conservation. Differences in the socio-economic and geographic characteristics of voters explain instead within-proposal variation (see also Halbheer et al. 2006 and Bornstein and Lanz 2008).

2.2 Local context

On March 8, 2015, the Swiss population voted on a popular initiative launched by the Green Liberal Party aiming at replacing the current value-added tax with an energy tax[1]. The Swiss government and all other parties but the Green Party were against the initiative. In spite of the low probability of success of the initiative, the business organizations invested important efforts in a campaign emphasizing the potential drawbacks of such proposal.

The Green Liberals pointed to the following main arguments in favor of the initiative:

- Tax dirty energy sources, making renewable energy sources competitive without subsidization and allowing for a transition towards a more sustainable economy
- Ensure fiscal neutrality, by keeping both the revenues for the government and the overall tax burden unchanged
- Reward environmentally-friendly consumers, by allowing them to save money on the VAT while rewarding environmentally-friendly behavior

[1]The maximum rate of the VAT is 8%. On the same day, the population also voted on a popular initiative of the Christian Democratic People's Party of Switzerland aiming at increasing fiscal exemptions for families with children. This initiative was rejected at 75.4%.

- Reinforce the local economy, increasing independence from oil producer states and incentivizing green innovation in Switzerland
- Avoid costs to firms, by eliminating an administratively burdensome tax such as VAT

The government shared in principle all these objectives, but not the mean to achieve them as proposed by the initiative. In February 2015 Switzerland was the first country to submit a pledge to the United Nations Framework Convention on Climate Change's pledge-and-review system. It pledged to reduce greenhouse gas emissions by 50% by 2030 with respect to the levels of 1990. However, the Swiss government opposed the intention to completely erase the VAT and replace it with an environmental tax, which is supposed to over time reduce energy consumption, i.e. its own tax base. The government stressed that the VAT revenues represent the main source of funding for the federal government, and during the debate a price of 5 francs per liter of gasoline was mentioned to compensate the fall in VAT revenues[2]. This would have implied a three-time increase in the price of gasoline. The government also mentioned a series of concerns related with the competitiveness and distributional effects of the proposed reform.

This scenario was rapidly appropriated by the political parties and organizations opposing the initiative, who claimed that the initiative would have:

- Led to unaffordable energy due to exploding energy prices, e.g. 5 francs per liter of gasoline
- Jeopardized the funding of crucial government's tasks, since contrary to the VAT, which represents a stable source of revenues, the energy tax rate would have had to be regularly increased (and so the price of energy) to maintain revenues
- Generated adverse competitiveness effects, putting the country's prosperity at risk due to a loss in competitiveness

We consider that the last argument resonated particularly strongly in that specific period, which followed by a few weeks only the decision of the Swiss National Bank to drop its euro peg. The ensuing appreciation of the Swiss franc was at the time expected to put under extreme pressure the many export-oriented sectors of the Swiss economy.

[2]Swiss franc close to parity with the US dollar at the time of the ballot.

The popular initiative was rejected at 92%. The Swiss government renounced to formulate a counter-proposal, but a few weeks after the ballot announced its strategy to meet the abovementioned pledges as well as to facilitate the planned phase out of nuclear energy (the so-called Energy Strategy 2050). This strategy consists in higher taxes on electricity and heating fuels, while the precise tax rates are left to further discussion and dependent on the final objectives in terms of greenhouse gas emissions abatement. Gasoline is also expected to be taxed, but only after a period of adaptation. We note that Switzerland introduced a carbon tax in 2008, but only on heating and process fuels. The current tax rate is 84 CHF per ton of CO_2.

3 Methodology

3.1 Analysis of voting behavior

Since 1977, the Swiss Centre of Expertise in the Social Sciences conducts the VOX survey after each federal ballot. 1500 observations are collected for each survey. We use these data to assess the determinants of voting behavior on the March 8 vote on energy taxes. VOX data are widely used to analyze voting behavior on different matters, as they perform well in terms of representativity and do not present the weaknesses of pure stated-preference studies. We took advantage of the strong presence of energy issues in the media at the time of this ballot and the debates following the presentation of the Swiss government's new energy strategy to administer a second survey. It uses a choice experiment format to elicit the acceptability of alternative energy tax designs (see below). Both surveys were carried out between March and May 2015.

In Switzerland, the rejection of a popular initiative is rather the rule, and not the exception. From 1891 to date, 9 out of 10 popular initiatives were rejected at the ballot box (sometimes after having influenced the legislative process). However, the rejection rate for this initiative is the second highest since 1891, the highest since 1929. This high rejection rate implies that voters from all government parties have contributed to reject the initiative, including the political left. The participation rate (42%) was slightly below the average participation rate for all popular votes during the period 1991-2014 (43.7%), the importance of the issue at stake being relatively low compared to the average ballot, and to hotter energy issues such as nuclear phasing-out.

3.2 Choice-experiment on alternative designs

3.2.1 Survey setting

Not all designs can be subject to vote. Previous research has shown the importance of the policy design for acceptability and it is thus crucial to have information on different policy attributes and the combination thereof. The only way to obtain such information from a relatively large sample – that is, larger than what is usually available in the laboratory – is to rely on stated preferences. It is however possible to set up a survey in a way that it makes choices and trade-offs the most realistic possible, such as with a choice experiment.

A choice experiment design allows putting the consumers, or voters, in a real-life situation and, thus, reduces the hypothetical bias. Furthermore, most of the focus is on the internal validity driven by the comparison of different designs. In our choice experiment, we present all respondents with three potential choices: two carbon taxes with two different designs and the status quo. By giving to respondents the possibility to reject all proposals, we are able to measure not only the relative preferences for a given policy attribute, but also the overall likelihood that a carbon tax can be accepted. The design of the proposed carbon taxes is the result of the combination of two attributes: the tax rate, measured in terms of Swiss francs per ton of CO_2 emitted, and the use of the tax revenues (see Table 1). Each respondent is requested to select one of the three options (two carbon tax designs and the status quo) in 8 different hypothetical ballots, with the attributes being randomly combined at each time. To increase precision in the identification of the attributes' effects, respondents are given one of the 15 randomly-generated versions of the questionnaire.

As all combinations included in the choice experiment were previously part of a modeling exercise, we are able to provide respondents with information on the order of magnitude for the expected impacts on the following items of each carbon tax design:

- Price of gasoline, diesel and heating fuel
- Greenhouse gas emissions abatements. When revenues are used to strengthen the environmental impact of the policy, we assume that foreign offsets are purchased and we thus also estimate the effect on greenhouse gas emissions abroad. We express this reduction in relative terms with respect to the emissions of Switzerland
- Purchasing power of average Swiss households, based on a proxy for overall consumption

TABLE 1: Choice experiment - attributes and levels

Attributes	Levels
Tax rate (CHF/tCO_2)	60
	90
	120
	150
Revenue recycling	Income tax rebates
	VAT rebates
	Lump-sum transfers
	Social redistribution
	Environmental earmarking

- Purchasing power of average low-income households

We provide realistic numbers based on scenarios for 2020 from a dynamic multi-sectorial multi-household general equilibrium model of the Swiss economy, called GENESwIS (see Vöhringer 2012)[3]. For a range of uniform carbon taxes of 60 to 150 CHF/tCO_2, the model achieves domestic emission reductions of 5-15%. Impacts on total consumption are generally negative, up to -0.5% for a tax rate of 150 CHF/tCO_2 combined with environmental recycling. As a notable exception, a small double dividend can be found for recycling through reductions of marginal income tax rates. Pure tax reforms with proportional rate reductions are regressive, and income tax recycling is the most regressive of the simulated variants. In contrast to this, lump-sum recycling renders the reform clearly progressive. International carbon offsets are cheap at the moment, and even very conservative assumptions allow for very sizable additional abatement abroad when carbon tax revenues are used for purchasing foreign offsets.

The aim of this simulation is to provide sufficient information for the most relevant variables that are supposed to guide voting behavior, replicating the effort that a government could do to introduce environmental taxes to the population. Since we carefully explain to respondents the functioning and effects

[3]In GENESwIS, households are disaggregated according to living standards and composition. Households and firms act rationally under perfect foresight and competition, and the government collects taxes and uses the revenue for public goods provision and social benefits (equal yield is assumed). Further standard features include international trade with an Armington assumption, labor-leisure choice, and a putty-clay representation for capital. GENESwIS is based on the 2008 energy related disaggregation of the Swiss Input-Output Table (Nathani et al. 2011), combined with the population census of the Swiss Federal Statistical Office (cf. Ecoplan 2012). Core elasticities of substitution that are relevant for carbon abatement have been taken from Mohler and Müller (2012).

of carbon taxes, we expect this specific setting to lead to different results with respect to what is most often found in the literature.

The recruitment of participants went as follows. A set of about 4'000 potential respondents was randomly selected and received by post mail the following material:

- A letter presenting the study, making participants familiar with the issue and encouraging them to participate in the survey if called by phone, following the guidelines of Harrison and List (2004)
- A detailed one-page fact sheet explaining how carbon taxes work and the main implications of each recycling option
- The full set of choice cards for all 8 votes displaying the attributes and related impacts as estimated by the computable general equilibrium model (see Figure A.1 for an example)

A randomly drawn sub-set of the about 4000 potential respondents was then contacted by phone and driven through the questionnaire. In total 1200 individuals were interviewed. When it came to taking a decision on the hypothetical ballots, all respondents were read a short and unique text describing the effects of each carbon tax type. This ensured that all respondents were provided with the same information, even those who had not spent time reading the material that they had received at home. As many already "voted" at home, respondents were given the possibility to skip the oral explanations[4].

3.2.2 Preferences for attributes and carbon taxes

Before identifying the determinants of individual support for a carbon tax, we hypothesize what they could be, based on our literature review:

Hypothesis 1: Tax rate We expect higher tax rates to lead to lower acceptability for carbon taxes, everything else equal

Hypothesis 2: Revenue recycling We expect acceptability to vary substantially depending on the use of revenues. We expect use of revenues for environmental purposes to increase acceptability the most, followed by social

[4]In Switzerland, people may be asked to vote several times a year. A few weeks before the day of voting, all potential voters receive by post mail written information about the ballot, so that they have the time to form their opinion and also vote by correspondence if wishing so. Our choice experiment is thus organized in a way that matches standard ballot procedures. We emphasize that information on proposed policies circulates widely also in democratic countries that do not use the instruments of direct democracy, even though in different forms.

cushioning addressing potential distributional effects. We expect lower acceptability with revenue-neutral recycling. Revenue neutrality (taxing here and reducing taxes elsewhere) is usually a criterion that the taxpayers do not request, or understand. This is particularly true in the absence of a double dividend. We do not have specific priors on the relative ranking within revenue-neutral recycling methods, i.e. income tax rebates, VAT reduction and lump-sum transfers

4 Empirical results

4.1 Analysis of voting behavior

The VOX survey mainly consists in a standard list of questions, unchanged from ballot to ballot, to which are added additional questions specific to each ballot (some of them on our request). Table 2 presents the main outcomes for our analysis along with other main variables of interest (see Table A.1 for descriptive statistics on the characteristics of our VOX respondents, Table A.2 for those of the choice-experiment sample and Table A.3 for the underlying population)[5]. As usual, the VOX ballot performs relatively well in predicting the ballot outcome. The frequency of no-votes in the survey, 90%, is indeed very close to the real outcome (92%). The survey overestimates instead to some extent participation, which was in reality 42%. We model participation below, along with the voting decision. Table 2 displays additional interesting statistics. For instance, we observe that most people take their decision on the vote on average 16 days, or about 2 weeks, before the ballot day. Only about 20% declare to have a set opinion from the start. This shows the importance of studying political acceptability in the presence of media coverage and political debates to capture the effect of (partisan) information on voters. Knowledge of the initiative is tested directly by the interviewers, based on an open question introducing the questionnaire.

The survey covers three arguments in favor, and three arguments against the initiative. These questions are asked only to respondents having participated in the ballot. Respondents can state their agreement or disagreement with such statements on a 1 to 4 Likert scale. The higher the score, the higher the agreement. In general, and not surprisingly comparing with the ballot outcome,

[5]Predictably, the surveys may slightly under-represent young individuals, and slightly overestimate educated, national and (by construction) Italian-speaking people. When appropriate, we control for these variables with our econometric models. Our main findings are unchanged if using sampling weights.

TABLE 2: VOX data: main outcomes and determinants of voting

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Voting decision					
No-vote	0.898	0.302	0	1	914
Participation	0.679	0.467	0	1	1509
Opinion formation					
Time of resolution before ballot day	-16.314	10.625	-1	-42	714
Immediate resolution	0.186	0.389	0	1	1514
Information					
Knowledge of the Energy Strategy 2050	2.767	0.861	1	4	1220
Knowledge of the initiative	0.661	0.473	0	1	1514
Agreement with arguments in favor					
Revenue neutrality	2.012	1.006	1	4	856
Environmental effectiveness	2.652	1.079	1	4	922
Energy security	2.652	1.079	1	4	922
Agreement with arguments against					
Competitiveness effects	3.026	1.004	1	4	908
Distributional effects	2.922	1.056	1	4	906
Decreasing tax base	3.002	1.012	1	4	852

arguments against the initiative score substantially higher than those in favor. In line with the literature, high concern is expressed for the competitiveness and distributional effects potentially generated by the implementation of the proposal. Another argument widely used by the opponents was that over time a decreasing tax base would have systematically implied higher tax rates, and so larger effects on the price of energy, on competitiveness and on the distribution of income. This argument also seems to have been well understood by the public. Consistently, the pro argument emphasizing revenue neutrality as a desirable property of the initiative did not receive much support, which corroborates the related stylized fact highlighted in the literature. The fact that higher fossil fuel prices would have resulted in a higher degree of independence from oil and gas exporters, and thus increased energy security, was moderately seen as a positive property of the energy tax. Among the pro arguments, the one that scores the highest relates with the effectiveness of energy taxes. The relative question asks respondents whether they believe that an energy tax creates incentives to save energy, and to switch to renewable energy. Yet, this straightforward question about the incentive effect of energy taxes does not receive massive support, and actually performs poorly in relative terms with respect to e.g. competitiveness concerns. Once again, we observe how the effectiveness of energy taxes is not an established fact for the general public, and its ability to change behavior is not shared by all the population.

We now analyze the determinants of voting behavior, and participation in the ballot. Since these two outcomes are jointly determined, we would face a selection problem if assessing voting behavior without taking into account the decision to participate or not in the ballot. We stress that participation is not compulsory in all cantons but one, the latter representing about 1% of the total population. We hence apply a standard Heckman selection strategy, and estimate jointly the probability to participate in the ballot, and to express either a "yes-" or a "no-vote". Since both outcomes are binary, we use a Heckman-selection probit model. The selection of variables follows Thalmann (2004), who had used comparable VOX data. We start with a reduced model including only "objective" socio-economic characteristics potentially affecting the decision to participate in the ballot, or to accept the initiative. We include gender, dummies for age categories, education, the number of cars in household (as a proxy for carbon footprint), and the location of the voter, in terms of linguistic region and with respect to the urban-rural cleavage. The procedure suggested in Thalmann (2004) implies running a second model, in which additional "subjective" variables are added to the "objective" model. From the standard questions of

the VOX survey, we indeed know some general preferences, political priorities and concerns of the voters in our sample, as reported by respondents. In line with Thalmann (2004), we consider as potentially relevant for this ballot the following variables: concern with unemployment, with income inequality, and with public intervention in the economy. We also include a variable capturing the political affinity as declared by the respondents, based on the stated political positioning at the last national elections. Given that only two parties supported the popular initiative, the Green Liberals, its promoters, and the Green Party, while all others strongly opposed it, including all leftist parties, we capture support for either one of the two parties as a measure of affinity with green parties (called "green affinity" hereafter).

The top panel of Table 3 presents the estimates for the "objective" model. All coefficients are statistically significant in the participation model. Most estimates carry the expected sign: both higher education and age are correlated to a higher likelihood to participate in a ballot. Participation rates are higher for male individuals and in German speaking areas compared to French (the dummy of reference) and Italian speaking areas. Rural areas also experience higher turnout. These differences are very similar to those found by Thalmann (2004), and mirror general voting behavior in Switzerland. Interestingly, car ownership is also associated with a higher ballot participation.

Taking into account self-selection into voting, the vote model assesses the effect of the previous variables on the likelihood to express a yes-vote in the ballot. Higher education is found to be positively correlated with pro-environmental behavior, a common finding in the literature already at the time of the theoretical and empirical analysis of Californian referenda by Deacon and Shapiro (1975). Females are less likely to support the initiative, while young generations and older individuals are less likely to support energy taxes, exactly as in Thalmann (2004). The intuition is the following. Elderly are expected to benefit less from climate change mitigation. For young voters, two opposing effects may be at play: they have a higher probability to experience climate change, but are possibly also more exposed to labor market shocks.

Interestingly, we find that, in statistical terms, car ownership explains participation only, and not voting behavior. Yet, we note the expected negative sign, as car ownership represents our proxy for exposure to higher energy prices.

The bottom panel of Table 3 introduces the subjective variables. Most of the previous results concerning participation are robust to the addition of general political concerns and affinity. Among the subjective variables, only concern with unemployment is significantly linked to participation, with a positive sign

TABLE 3: Heckman-selection probit model

	Vote model				Participation model	
	Coefficients	(S.E.)	Marginal effects	(S.E.)	Coefficients	(S.E.)
Objective model						
Gender (1 = F)	-0.250**	(0.107)	-0.029**	(0.012)	-0.138*	(0.074)
Young (1 = 18-29 years)	-0.642***	(0.224)	-0.074***	(0.025)	-0.940***	(0.118)
Elderly (1 = 60+ years)	-0.180*	(0.119)	-0.021*	(0.013)	0.678***	(0.086)
German speaking	0.204	(0.126)	0.023	(0.014)	0.280**	(0.086)
Italian speaking	-0.145	(0.190)	-0.017	(0.022)	-0.540***	(0.107)
Education (1 = high school+)	0.274**	(0.116)	0.032**	(0.013)	0.277***	(0.077)
Number of cars in household	-0.084	(0.097)	-0.010	(0.011)	0.140**	(0.041)
Municipality is rural	-0.098	(0.129)	-0.011	(0.015)	0.271**	(0.089)
Intercept	-1.418**	(0.193)			-0.010	(0.120)
N			1403			
Censored observations			489			
Uncensored observations			914			
Full model						
Gender (1 = F)	-0.240**	(0.119)	-0.024**	(0.012)	-0.123	(0.078)
Young (1 = 18-29 years)	-0.561*	(0.277)	-0.056**	(0.026)	-0.936***	(0.120)
Elderly (1 = 60+ years)	-0.044	(0.129)	-0.004	(0.013)	0.671**	(0.089)
German speaking	0.140	(0.137)	0.004	(0.014)	0.265***	(0.090)
Italian speaking	0.092	(0.204)	-0.009	(0.020)	-0.605***	(0.090)
Education (1 = high school+)	0.145	(0.127)	0.015	(0.013)	0.268***	(0.079)
Number of cars in household	-0.003	(0.083)	-0.0003	(0.008)	0.113***	(0.042)
Municipality is rural	0.018	(0.138)	0.002	(0.014)	0.291***	(0.091)
Concern with unemployment	-0.063	(0.046)	-0.006	(0.005)	0.060**	(0.027)
Concern with income inequality	-0.103***	(0.038)	-0.010***	(0.004)	0.022	(0.024)
Concern with public intervention	-0.068*	(0.037)	-0.007*	(0.004)	-0.015	(0.023)
Green affinity	1.168***	(0.177)	0.117***	(0.022)	0.068	(0.159)
Intercept	-0.557	(0.338)			-0.378*	(0.221)
N			1318			
Censored observations			455			
Uncensored observations			863			

Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

as expected. The positive but non-significant effect for green affinity suggests that the sponsors and supporters of the initiative were not really able to mobilize their voters to participate in the ballot .The picture is slightly different for voting choice. Only gender and the age dummy for the youngest voters significantly affect the decision to cast a yes-vote in the ballot. The subjective variables seem to substantially contribute to explain variation in the model. In particular, we note how green affinity is linked to a higher propensity to support the initiative of the Green Liberals[6]. While the marginal effect is relatively small in absolute value, with only a 10% higher probability to vote yes for respondents declaring themselves as greens, the magnitude of this effect is very large in relative terms. Green voters may have intrinsically supported the initiative, or voted strategically in favor to avoid a major defeat. Polls were indeed forecasting a rejection as the most probable outcome, even though such debacle came clearly unexpected. In line with predictions, concern with income inequality, with public intervention, and with unemployment are associated with a negative coefficient, while the latter not in a statistically significant way. That is, the subjective variables seem to capture the main complaints with the proposal. To better understand the major impediments to a yes-vote, we exploit the pros and cons as introduced by Table 2. We recall that these variables are observed only for the respondents declaring to have participated in the ballot. Hence, we run a simple probit model, skipping the participation stage. Outcomes of interest are compared with the estimates of Table 3.

Table 4 shows the estimates for this additional model. Among the objective variables, only one significantly explains voting behavior once taking into account subjective variables and opinions on the popular initiative. This variable is the number of cars in the households, which now reaches statistical significance. That is, as in Thalmann (2004), the number of cars could be a measure of people's economic sensitivity to higher energy prices, as families with more cars are less likely to approve the initiative. Concerning subjective variables, the concern for public intervention remains significant, and its magnitude virtually unchanged with respect to Table 3. Green affinity keeps its significance, although the marginal effect is reduced. People's opinions on the pro and con arguments mentioned by the survey are the main drivers of voting behavior. All variables have the expected sign, and comparable magnitudes. Only the coeffi-

[6]Given the small proportion of green voters, we estimate the joint effect of supporting either one of the two green parties. Both variables would positively affect the probability of casting a yes-vote if used separately. If additional variables for other parties would be included in the model, a negative and significant marginal effect could be found for supporting a centre-right party called FDP, or "The Liberals". Besides these facts, no clear right-left pattern could be discerned in the voting model. All additional estimations are available by the authors upon request.

TABLE 4: Probit model including pros and cons

	Coefficient	(S.E.)	Marginal effects	(S.E.)
Gender (1 = F)	-0.311	(0.203)	-0.011	(0.008)
Young (1 = 18-29 years)	-0.478	(0.427)	-0.017	(0.016)
Elderly (1 = 60+ years)	-0.301	(0.207)	-0.011	(0.009)
German speaking	0.256	(0.278)	0.009	(0.010)
Italian speaking	0.080	(0.360)	0.003	(0.013)
Education (1 = high school+)	-0.130	(0.217)	-0.005	(0.008)
Number of cars in household	-0.457**	(0.132)	-0.016**	(0.007)
Rural municipality	-0.051	(0.228)	-0.002	(0.008)
Concern with unemployment	-0.042	(0.079)	-0.002	(0.003)
Concern with income inequality	0.019	(0.065)	0.0006	(0.002)
Concern with public intervention	-0.085*	(0.059)	-0.003*	(0.002)
Green affinity	0.628**	(0.260)	0.022**	(0.011)
Revenue neutrality	0.617***	(0.103)	0.022**	(0.007)
Environmental effectiveness	0.378***	(0.110)	0.013**	(0.005)
Energy security	0.181*	(0.108)	0.007*	(0.004)
Competitiveness effects	-0.394**	(0.094)	-0.014**	(0.005)
Regressive effects	-0.165*	(0.089)	-0.006*	(0.003)
Decreasing tax base	-0.057	(0.099)	-0.002	(0.003)
Intercept	-1.567*	(0.848)		
N			607	
Pseudo R^2			0.503	

Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, ** $p < 0.01$.

cient for the argument that a decreasing tax base could be problematic is too small to be statistically significant. The adverse consequences of a decreasing tax base may already be accounted for by the other variables.

When looking at the marginal effects for these arguments, we observe that the Green Liberals' popular initiative was rejected based on the very same contrary arguments that are most often mentioned in the literature. Similarly, the pro arguments contributed to higher acceptability, but their lower uptake among the general public, again in line with the literature, did not help to substantially move the balance in favor of the reform.

For instance, the higher the agreement with revenue neutrality being considered a positive aspect of the proposed reform, the higher the likelihood to have voted yes. Yet, on average people were not particularly enthusiastic about revenue neutrality. The same applies to the energy security argument, whose agreement is also linked to a higher probability of approving the proposal. A recurrent finding concerning the perception of environmental effectiveness, largely discussed in the introductory parts, is corroborated by our ballot data. Being relatively confident that energy taxes provide an incentive to decrease energy consumption and to switch to cleaner sources is linked with a higher probability of a yes-vote. The magnitude of this effect may look relatively small if we compare with other survey studies testing the effect of perceived effectiveness on acceptability in a similar fashion, such as Baranzini and Carattini (2016). However, assessing the relevance of this and the other effects should take into account the overall outcome of the ballot, very well replicated by the VOX survey. In this light, the effects that we measure are considerable.

Similar considerations apply to the contrary arguments. The only difference is that these were on average considered as much more relevant than the arguments concerning pros. Competitiveness effects were already determinant in the ballot analyzed by Thalmann (2004), in spite of an unemployment level below 2% at that time in Switzerland. At the time of the ballot that we analyze, the unemployment rate was comfortably below 4%. Similarly to other contexts, competitiveness concerns often take the center stage when it comes to take important political decisions on climate policy. This can happen in spite of the overall minimal adverse effects on competitiveness observed so far (cf. e.g. Mathys and de Melo 2011). For instance, when designing their carbon taxes, Scandinavian countries opted for very generous exemptions to energy-intensive industries on competitiveness grounds, avoiding important profit losses to the firms concerned, but also watering down the environmental effects of the policy (Baranzini and Carattini 2014). The industry-flight argument and related

TABLE 5: Preferred modes of recycling

Variable	Mean	Std. Dev.	Min.	Max.
Subsidies for efficiency and renewables	0.568	0.496	0	1
Social cushioning	0.115	0.320	0	1
Reduction in existing taxes	0.13	0.337	0	1
Redistribution to households and firms	0.186	0.389	0	1

fears of substantial competitiveness effects largely contributed to the policy reversal observed in the case of the Australian carbon tax (cf. Spash and Lo 2012). Hence, the general public may tend to overestimate competitiveness effects, and this may be the result of very effective political campaigning from energy-intensive industries and fossil energy providers (cf. Ingold and Varone 2012).

Following the previous argument, we complete the analysis by testing the potential popularity of alternative recycling schemes. Two specific questions were introduced to respondents, asking them to mention their preferred recycling option, freely, first, and then among a list of four options. These options are: subsidies for efficiency improvements and renewable energy (environmental earmarking), social cushioning, reduction in existing taxes, and redistribution to households and firms. Most answers given in the open question correspond to one of these four categories. The results of the open question, in which respondents are not influenced by the options given by the questionnaire, are thus very similar to those of the closed question, displayed in Table 5.

Unsurprisingly, about 60% of respondents would like revenues from energy taxes to be used in the environmental domain. This result confirms previous findings in the literature, and suggests that Swiss voters are not different from the other samples analyzed so far. Only a small fraction of the population would use tax revenues to provide social cushioning, or to reduce existing taxes, and that in spite of the concerns expressed for distributional and competitiveness effects. Similar findings on this apparent inconsistency were already provided by Baranzini and Carattini (2016), based on a specific Swiss canton. Apparently, such concerns affect the decision to accept of not an energy tax at a given tax rate, but do not call for a diversion of revenues from environmental earmarking. Redistribution to households and firms, the current way of redistributing revenues from the existing Swiss carbon tax on heating fuels, is supported by

about one fifth of the sample only[7]. That is, if voters were asked to vote on the use of revenues of the current scheme, and absent any additional information, they would probably reject lump-sum transfers, and favor a switch towards full earmarking of revenues.

4.2 Choice experiment on alternative carbon tax designs

In this section we analyze decision making in our full-information choice-experiment setting and compare it with the observed real voting behavior, and with the previous literature, with the aim of testing our two main hypotheses concerning tax rates and recycling modes. Table 6 presents our main estimates. All columns display marginal effects from conditional logit. Column (1) shows estimates for the full sample, i.e. 1189 individuals. Since we survey a representative sample of the population living in Switzerland, not all respondents are Swiss nationals and so entitled to vote. Hence, column (2) restricts the sample to nationals only. Among nationals, we know self-declared participation to the usual four ballots per year. Column (3) excludes non-voters while column (4) retains only people declaring 100% ballot participation. Since all results remain the same in qualitative terms and most of the time also in quantitative terms, we discuss results based on column (1). The fact that we find similar results for different sub-samples is however an interesting finding in itself. That is, foreign respondents would not vote differently than Swiss citizens, according to this sample and for this matter. If we exclude those individuals that are most likely to abstain to better predict the outcome of a potential ballot, the results are also virtually unchanged. The propensity to vote seems thus to have no influence on how people perceive the tax designs proposed in our study, in spite of the non-negligible changes in observations across columns.

As expected, a higher tax rate is linked to a lower acceptability, everything else equal. This follows from economic theory and is in line with Sælen and Kallbekken (2011), Brannlund and Persson (2012) and Gevrek and Uyduranoglu (2015). However, the difference between 0 and 60 francs is relatively small in comparison with the other tax rates. Hence, in some situations, people might have preferred a carbon tax, with a moderate tax rate, than no carbon tax at all. Given that the tax rate of the current Swiss carbon tax on heating fuels was already fixed at 60 francs at the time of the survey, we did not include in the survey a lower tax rate, e.g. of 30 francs. Furthermore, we note that except for the first step from 0 to 60 francs, the progression is almost linear, suggesting

[7]Note that up one third of revenues are earmarked for subsidies for energy efficiency in buildings.

that a well-shaped linear demand would be a good approximation for the case of carbon taxes.

This linearity allows speculating on the negative impact on acceptability of an extremely high rate, as the one suggested by the popular initiative promoted by the Green Liberals and rejected by the Swiss population. While promoters of and opponents to the popular initiative were disagreeing on the proposal's expected impact on energy prices, depending on the time horizon that they used in their campaigning, our most conservative computations suggest that in the short term the tax rate would have had to be of at least 300 CHF per ton of CO_2 to replace the revenues of the VAT. Figure 1 extrapolates linearly from the probabilities of success that we observe based on the tax rates proposed by the survey and predicts the outcome of an initiative proposing a tax rate of 300 CHF per ton of CO_2 (see Table A.4 for descriptive statistics). For a like-to-like comparison, Figure 1 shows only the predicted likelihood of success if revenues were to be used as proposed by the Green Liberals. While interpreting any out-of-sample prediction always requires a lot of precaution, our extrapolation provides support for the external validity of our choice experiment. At a rate of 300 CHF per ton of CO_2 the predicted support is virtually zero, which is very close to the share of yes-votes in the public ballot. That is, if anything, our choice experiment predicts lower support than the ballot.

The Green Liberals' popular initiative could probably have had a better outcome with a different use of tax revenues. As the estimates show, reducing the current value added tax is not linked to any higher acceptability with respect to income tax rebates (the reference case, omitted due to multicollinearity). Together, these two revenue-recycling options are the most unpopular. This result comes as expected and confirms our hypothesis on the low support for revenue neutrality. In this respect, it is important to recall that based on the modeling exercise we find none or little double dividend with these two ways to recycle revenues, the net effect on the domestic purchasing power being broadly as negative as with the other types of recycling. This confirms a general result in the double-dividend literature (Goulder 1995). Hence, respondents informed about the potential beneficial effects of reducing distortionary taxes knew that they should not be expecting a double dividend from lower income taxes or a reduction in the value-added tax.

We are however surprised by the estimates concerning lump-sum transfers, environmental recycling and to some extent social cushioning. The results that we provide for these variables are novel in the literature and deserve to be analyzed carefully. The signs for these variables are positive, negative and positive,

TABLE 6: Choice experiment - Estimates from conditional logit

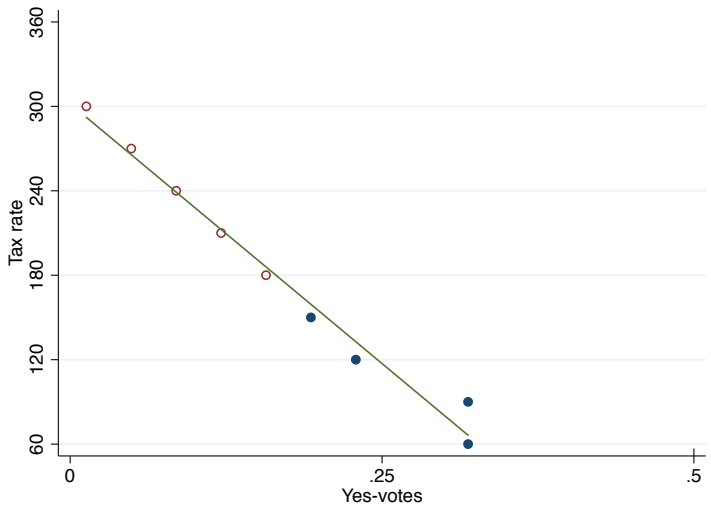
	Full sample	Nationals	Without no-voters	Always voters
	(1)	(2)	(3)	(4)
Tax rate				
0 CHF (reference)				
60 CHF	-0.018	-0.030	-0.037**	-0.043*
	(0.015)	(0.016)	(0.067)	(0.020)
90 CHF	-0.052***	-0.059***	-0.065***	-0.070***
	(0.015)	(0.016)	(0.017)	(0.021)
120 CHF	-0.107***	-0.122***	-0.123***	-0.122***
	(0.015)	(0.016)	(0.017)	(0.020)
150 CHF	-0.177***	-0.186***	-0.193***	-0.200***
	(0.018)	(0.016)	(0.017)	(0.02)
Revenue recycling				
Income tax rebate (reference)				
VAT reduction	-0.013	-0.010	-0.012	-0.016
	(0.011)	(0.012)	(0.013)	(0.016)
Lump-sum redistribution	0.137***	0.136***	0.135***	0.127***
	(0.012)	(0.012)	(0.013)	(0.016)
Social cushioning	0.144***	0.145***	0.144***	0.135***
	(0.011)	(0.012)	(0.012)	(0.016)
Environmental recycling	-0.021	-0.029*	-0.035**	-0.056**
	(0.013)	(0.014)	(0.014)	(0.018)
Number of individuals	1189	1066	980	650
Number of hypothetical votes	28536	25584	23520	15600
Pseudo-R^2	0.0342	0.0360	0.0351	0.0404

Note: Estimates report marginal effects from conditional logit.

The dependent variable measures the acceptability of the proposed carbon tax designs.

Robust standard error in parentheses. * $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$.

FIGURE 1: Prediction with VAT recycling as in the Green Liberals' initiative



Note: Filled circles indicate observations in the sample, empty circles indicate observations obtained through extrapolation.

respectively. That is, we find that lump-sum transfers and social cushioning are the most preferred options for recycling, while environmental recycling does not seem to obtain the support that it usually does in the literature. We have an explanation for all the three facts, as well as important policy implications.

Let us start with the relatively high acceptability of the lump-sum redistribution. The modeling exercise suggests moderate net gains for low-income households with lump-sum transfers. Only social cushioning does better, while the remaining types of recycling involve regressive effects. Respondents are informed about this fact and can internalize the beneficial distributional properties of lump-sum redistribution. Furthermore, respondents are informed by the introductory material that the current carbon tax on heating fuels is mostly redistributed through lump-sum transfers and it may be that this information could have increased the legitimacy of this type of recycling. This information is public, but according to Baranzini and Carattini (2016) only a limited number of individuals are aware of the current carbon tax on heating fuel, and an even smaller proportion knows how its revenues are redistributed (one fourth of the 1012 respondents interviewed in INFRAS 2015).

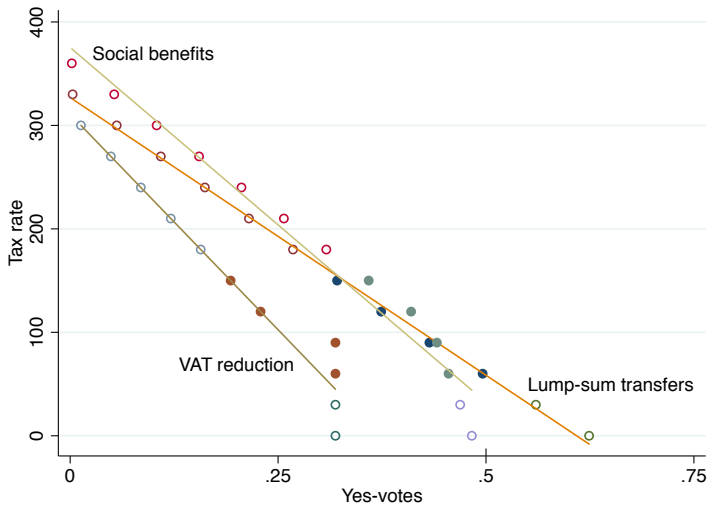
However, the most important finding concerns the low demand for recycling

for environmental purposes. This result is at odds with most of the literature on the acceptability of environmental taxes previously discussed. This is the first study providing survey respondents with an estimate of the emission abatements linked with the carbon taxes about which respondents are requested to express their opinion. Interviewers were instructed on how to provide simple explanations on the price sensitivity of consumers and they reportedly had to use such information to answer the general public's curiosity on the economic bases for the figures for emissions abatements included in the choice cards. That is, our survey addressed by construction one of the main obstacle to carbon taxes: perceived ineffectiveness, which often goes hand in hand with earmarking for environmental purposes. Since all carbon taxes in the survey are shown to be effective, and to the extent that the scientific credibility of our study was not challenged by respondents, the main driver for the demand for environmental recycling is wiped out. We also note that the demand for environmental recycling expressed so often in the literature may not necessarily correspond to the most effective way of obtaining additional emission abatements as economists would interpret it. Even with a conservative estimate for the price of emissions on foreign carbon markets, the revenues of a carbon tax between 60 and 150 francs per ton of CO_2 can lead to very large emission abatements abroad. All scenarios imply substantial negative emissions: even the lowest tax rate is shown to lead to abatements equivalent to five times Swiss emissions. Therefore, at the current carbon price levels, it would be very tempting for policymakers to purchase many years of carbon neutrality and so achieve long-term pledges, such as "the balance" between emissions and removals by sinks, at an extremely low cost. However, we understand that the respondents in our survey may wonder why compensating so much. The general public may also do not like the purchase of foreign carbon credits more in general. People may have a preference for local investments, which provide a number of local co-benefits, and may also have ethical or practical reservations with respect to the use of offsets in general (see Conte and Kotchen 2010; Anderson 2012; Carattini and Tavoni 2016).

Finally, the relative popularity of social cushioning does not completely surprise, given that distributional effects were made completely salient to respondents. Social cushioning is shown to provide the most progressive effects over all types of recycling, although lump-sum transfers perform similarly with moderate tax rates.

Figure 2 extends the simulation of Figure 1 with the most popular recycling options, lump-sum recycling and social cushioning. As Figure 1 already showed, our exercise suggests that even with an extremely low tax rate recycling through

FIGURE 2: Prediction with alternative recycling compared to VAT recycling



Note: Filled circles indicate observations in the sample, empty circles indicate observations obtained through extrapolation.

VAT rebates could hardly provide a majority in favor of a carbon tax. With social cushioning, and especially lump-sum transfers, the picture is different. While none of the two recycling options lead us to a majority with the tax rates considered by our survey, the prediction for recycling through lump-sum transfers suggests that anything below 60 CHF per ton of CO_2 would be in principle acceptable. This was the rate of the carbon tax at the time of the vote (since 2016 it is at 84 CHF), but it applies only to heating and process fuels, not vehicle fuels. While we recall the necessary precautions in taking at face values such predictions, we stress how recycling modes can completely shift the demand for carbon taxes, possibly also beyond the required threshold to make them acceptable. Based on these findings, we reformulate hypothesis 2 as follows:

Hypothesis 2: Revenue recycling We expect acceptability to vary substantially depending on the use of revenues. In relative terms, we expect lower acceptability with revenue-neutral recycling, as revenue neutrality (taxing here and reducing taxes elsewhere) is shown to be a criterion that the taxpayers probably generally do not request, or understand. This is particularly true in the absence of a double dividend. Lump-sum redis-

tribution can however be associated to higher acceptability provided that its progressive properties are made explicit. If distributional effects are salient, social cushioning and lump-sum redistribution can lead to higher acceptability. Providing information on the effectiveness of the carbon tax reduces the usual demand for revenue recycling for environmental reinforcement. Some types of environmental recycling may even cause lower support, such as recycling through the purchase of foreign carbon credits.

Finally, we consider how exploiting heterogeneity across individuals may provide further information on people's preferences for carbon taxes. Similarly to e.g. Gevrek and Uyduranoglu (2015), we apply a latent-class model to explain heterogeneous preferences. According to our data, 5 latent classes can be identified[8]. Table A.5 in the Appendix displays how preferences change across classes, based again on a conditional logit model. Table A.6 introduces information on the characteristics of respondents, aiming at describing the composition of classes using a multinomial logit model[9].

We briefly summarize the insights from this additional analysis. Classes are divided based on the importance given to each attribute (price or revenue recycling), on the preference for revenue recycling, the elasticity to variation in the tax rate, and overall acceptability. Low-income households tend to be associated with classes showing a marked preference for progressive designs, i.e. through lump-sum redistribution of revenues or social cushioning. The overall degree of acceptability, and the related sensitivity to tax rates, seems to be linked to different degrees of climate concern. Classes with lower degrees of climate concern tend to be linked to rather elastic behavior, and low to moderate overall acceptability. While a positive correlation between concern for climate mitigation and preferences for tighter climate policy is common in the literature (see Drews and van den Bergh 2015), we are, to the best of our knowledge, the first to empirically document different preferences for the distributional effects of carbon taxes across the income distribution.

4.3 Discussion

Tax rate We find that higher tax rates clearly imply lower acceptability. This fact recalls once again the general public's sensibility with respect to the cost of climate policy, above all when the latter is as transparent as with carbon taxes.

[8]AIC (BIC) values are given as follows: for two classes, 15495 (15616); for three classes, 14835 (15021); for four classes, 14620 (14870); for five classes, 14427 (14741).

[9]The number of observations is limited for a series of variables, such as income or commuting preferences for workers.

As pointed out in the literature, this reminds policymakers of the importance of proceedings in small steps (Baranzini and Carattini 2014). Starting at a moderate price level may also reduce the opposition from energy-intensive lobbies, even though some evidence suggests that vested interests may be mobilized against any departure from the status quo (see e.g. Rocchi et al. 2014)[10]. In this respect, it is important that policymakers have at their disposal estimates of the potential competitiveness effects of carbon taxes. These are indeed likely to be small overall and should not be overemphasized. Our results suggest that the general public is likely to be ready to give up some fraction of national income, if they have no doubts on the environmental effectiveness of the measures that they are supporting. Hence, resistance to carbon taxes seems not to be due to complete free riding in the provision of the global public good which is climate change mitigation, thus supporting the idea of some degree of cooperation in the climate commons (cf. Ostrom 2009; Carattini et al. 2015; Carattini 2015).

Gradual introduction and information The acceptability for a given instrument may increase once the instrument is in place, supporting the use of moderate tax rates to start. This for three reasons. First, the role of relative consumption: once the tax in place, people realize that their purchasing power compared to the others around them may be actually unchanged (Howarth 2006; Gowdy 2008). Second, the role of revenue recycling: revenue neutrality can increase acceptability *ex post*, once people see that they are given some of the money back. Of course, this requires the redistribution of revenues to be sufficiently salient. With full redistribution, some households may be net winners, as with feebates. Third, the role of observing the functioning of the policy: as discussed, the general public tends to underestimate the effectiveness of environmental taxes, especially absent any recycling for environmental purposes. However, if the effect of the policy is sufficiently salient, people may review their beliefs *ex post*, causing an important gap between perceived effectiveness (and thus acceptability) *ex ante* and *ex post*. Evidence in this sense is provided for instance by Carattini et al. (2016), who exploit the forced implementation of pricing garbage by the bag on a relatively large population to assess its overall effectiveness, and its acceptability both before and after the implementation. People are very concerned with pricing *ex ante*, but implementing the policy substantially reduces concerns with effectiveness and fairness. Similarly, Kallbekken and Sælen (2011) have argued in favor of the use of trial periods, based

[10]The descriptive statistics in Table A.2 report that a substantial majority of the choice-experiment sample would have a preference for a carbon tax that starts low and increases over time.

on the successful example of the Stockholm congestion charge (see also Cherry et al. 2014). In the specific case of carbon taxes, Murray and Rivers (2015) show based on poll data how resistence against British Columbia's carbon tax substantially decreased after its introduction, with positive spillovers to the rest of Canada. In the case under consideration, we note that although Switzerland has already a carbon tax on heating and process fuels, an important fraction of the population is not aware of its existence.

Our choice experiment was designed to inform voters on the effectiveness of the incentive tax, something that is generally missing in similar studies in the literature as well as in the political arena.

Revenue recycling Selling an environmental tax reform may be hard, but not impossible. Our findings from the choice experiment support the decision of the Swiss government to go for full lump-sum recycling in the planned extension of the current carbon tax on heating fuels to all fuels, as announced in March 2015. However, our specific framework provides more detailed information that usually done in the public arena. As emphasized based on the VOX data, absent any additional information the general public would probably reject lump-sum transfers in favor of environmental earmarking. That is, policymakers should be willing to undertake the effort that is needed to reduce the informational gap between them and the general public. In our case, we provided respondents with clear and concise information on how carbon taxes work, on the mechanisms through which higher energy prices lead to lower energy consumption – including scenarios for emission abatements – and on the competitiveness and distributional effects of each type of revenue recycling for any given tax rate. Explaining how lump-sum redistribution works and how it can be progressive will be a first step in favor of higher acceptability of revenue-neutral designs.

We also believe that providing figures for the expected emission abatements will also improve acceptability and decrease the demand for environmental recycling. In this case we stress how it is crucial to explain to the population how the incentive effect works. These figures could also emphasize the existence of co-benefits for the local population. Expecting positive co-benefits is indeed associated with higher willingness to pay for climate change mitigation (Longo et al. 2012) as well as higher acceptability of carbon taxes (Baranzini and Carattini 2016).

5 Conclusions

Pledges are not *per se* credible policy commitments. The ability of countries to turn pledges into cost-effective policies such as carbon taxes will determine the possibility to ramp up future ambitions and to push for further policy tightening. The implementation of carbon taxes has experienced a hard time in many countries, so far. Learning from these experiences is crucial to increase their popularity and broaden their implementation in a post-Paris world.

This paper analyzes voting behavior in a real ballot on energy taxes in Switzerland. Revenues from these energy taxes were to replace completely the current value-added tax. The proposal was massively rejected. We collect data on a large representative sample of voters. We find that several obstacles limited its acceptability, such as distributional and competitiveness concerns and perceived environmental ineffectiveness. Given the perception of little environmental effects, revenue neutrality is not a priori a solution for the general public. These energy taxes would have instead been more popular if revenues were to be earmarked for environmental purposes.

At the same time of the ballot, we administer a choice-experiment survey, exploiting the salience of the topic. The choice experiment addresses all the obstacles emphasized by the analysis of real voting behavior. Based on a computable general equilibrium model, it provides information to all respondents on the social, economic and environmental impacts for different tax rates and use of revenues. We analyze the demand for carbon taxes for each design and show that this information leads to a very different outcome compared to the ballot and the literature. First of all, revenue-neutral policies can become popular, provided that their progressive properties are emphasized as in the case of lump-sum transfers. Second, environmental earmarking may no longer be absolutely necessary to receive a substantial support for carbon taxes, if information is provided on their environmental effectiveness.

Based on our findings we argue that policy designs usually preferred by economists, but in most cases opposed by the general public, are not necessarily unpopular, provided that the general public shares at least some of the information that economists have. Our findings can help devise effective carbon taxes that are accepted by citizens, because they are convincingly shown to be environmentally effective and because their revenues are refunded in a form that mitigates their burden on low-income households. Addressing the concerns and limited information of the general public is probably the only way to avoid important resistances to cost-effective instruments of climate change mitigation,

which could put at risk the realization of the current pledges and potentially jeopardize their necessary tightening. The consequences are known. The inability to turn Paris pledges into policy would this time hardly leave any room to avoid running into dangerous climate changes.

References

Anderson, K. (2012). The inconvenient truth of carbon offsets. *Nature News 484*(7392), 7.

Baranzini, A., J. v. d. Bergh, S. Carattini, R. Howarth, E. Padilla, and J. Roca (2015). Seven reasons to use carbon pricing in climate policy. Working Paper wpdea1507, Department of Applied Economics at Universitat Autonoma of Barcelona.

Baranzini, A. and S. Carattini (2014). Taxation of emissions of greenhouse gases. In B. Freedman (Ed.), *Global Environmental Change*, Number 1 in Handbook of Global Environmental Pollution, pp. 543–560. Springer Netherlands.

Baranzini, A. and S. Carattini (2016). Effectiveness, earmarking and labeling: testing the acceptability of carbon taxes with survey data. *Environmental Economics and Policy Studies*, 1–31.

Baranzini, A., J. Goldemberg, and S. Speck (2000). A future for carbon taxes. *Ecological Economics 32*(3), 395–412.

Bornstein, N. and B. Lanz (2008). Voting on the environment: Price or ideology? Evidence from Swiss referendums. *Ecological Economics 67*(3), 430–440.

Brannlund, R. and L. Persson (2012). To tax, or not to tax: Preferences for climate policy attributes. *Climate Policy 12*(6), 704–721.

Bristow, A. L., M. Wardman, A. M. Zanni, and P. K. Chintakayala (2010). Public acceptability of personal carbon trading and carbon tax. *Ecological Economics 69*(9), 1824–1837.

Carattini, S. (2015). Green consumers and climate policy: Reconciling Ostrom and Nyborg, Howarth and Brekke. SSRN Scholarly Paper ID 2671328, Social Science Research Network.

Carattini, S., A. Baranzini, and R. Lalive (2016). Is taxing waste a waste of time? Evidence from a supreme court decision. Working Paper 227, Grantham Research Institute on Climate Change and the Environment, LSE.

Carattini, S., A. Baranzini, and J. Roca (2015). Unconventional determinants of greenhouse gas emissions: The role of trust. *Environmental Policy and Governance 25*(4), 243–257.

Carattini, S. and A. Tavoni (2016). How green are economists? Nota di Lavoro 2016.043, Fondazione Eni Enrico Mattei, Milan, Italy.

Cherry, T. L., S. Kallbekken, and S. Kroll (2012). The acceptability of efficiency-enhancing environmental taxes, subsidies and regulation: An experimental investigation. *Environmental Science & Policy 16*, 90–96.

Cherry, T. L., S. Kallbekken, and S. Kroll (2014). The impact of trial runs on the acceptability of environmental taxes: Experimental evidence. *Resource and Energy Economics 38*(C), 84–95.

Conte, M. N. and M. J. Kotchen (2010). Explaining the price of voluntary carbon offsets. *Climate Change Economics 01*(02), 93–111.

Deacon, R. T. and P. Shapiro (1975). Private preference for collective goods revealed through voting on referenda. *American Economic Review 65*(5), 943–55.

Deroubaix, J.-F. and F. Lévèque (2006). The rise and fall of French Ecological Tax Reform: Social acceptability versus political feasibility in the energy tax implementation process. *Energy Policy 34*(8), 940–949.

Dietz, S., C. Marchiori, and A. Tavoni (2012). Domestic politics and the formation of international environmental agreements. Working Paper 100, Centre for Climate Change Economics and Policy.

Dresner, S., L. Dunne, P. Clinch, and C. Beuermann (2006). Social and political responses to ecological tax reform in Europe: An introduction to the special issue. *Energy Policy 34*(8), 895–904.

Drews, S. and J. C. J. M. van den Bergh (2015). What explains public support for climate policies? A review of empirical and experimental studies. *Climate Policy*.

Ecoplan (2012). Volkswirtschaftliche Auswirkungen einer ökologischen Steuerreform – Analyse mit einem berechenbaren Gleichgewichtsmodell für die Schweiz. Technical report, Bundesamt für Energie, Eidgenössische Steuerverwaltung und Eidgenössische Finanzverwaltung, Berne.

Fankhauser, S., C. Gennaioli, and M. Collins (2015). Do international factors influence the passage of climate change legislation? *Climate Policy*.

Fischel, W. A. (1979). Determinants of voting on environmental quality: A study of a New Hampshire pulp mill referendum. *Journal of Environmental Economics and Management 6*(2), 107–118.

Fort, R. and D. N. Bunn (1998). Whether one votes and how one votes. *Public Choice 95*(1/2), 51–62.

Gevrek, Z. and A. Uyduranoglu (2015). Public preferences for carbon tax attributes. *Ecological Economics 118*, 186–197.

Goulder, L. H. (1995). Environmental taxation and the double dividend: A reader's guide. *International Tax and Public Finance 2*(2), 157–183.

Gowdy, J. M. (2008). Behavioral economics and climate change policy. *Journal of Economic Behavior & Organization 68*(3–4), 632–644.

Halbheer, D., S. Niggli, and A. Schmutzler (2006). What does it take to sell environmental policy? An empirical analysis of referendum data. *Environmental & Resource Economics 33*(4), 441–462.

Harrison, G. W. and J. A. List (2004). Field experiments. *Journal of Economic Literature 42*(4), 1009–1055.

Howarth, R. B. (2006). Optimal environmental taxes under relative consumption effects. *Ecological Economics 58*(1), 209–219.

INFRAS (2015). Klimaschutz und Grüne Wirtschaft - was meint die Bevölkerung? Ergebnisse einer repräsentativen Bevölkerungsbefragung - Schlussbericht. Technical report, Bundesamt für Umwelt, Zurich.

Ingold, K. and F. Varone (2012). Treating policy brokers seriously: Evidence from the climate policy. *Journal of Public Administration Research and Theory 22*(2), 319–346.

IPCC (2014). Fifth assessment report - Mitigation of climate change. Technical report.

Jacobsen, G. D. (2011). The Al Gore effect: An Inconvenient Truth and voluntary carbon offsets. *Journal of Environmental Economics and Management 61*(1), 67–78.

Jordan, A. J., D. Huitema, M. Hildén, H. v. Asselt, T. J. Rayner, J. J. Schoenefeld, J. Tosun, J. Forster, and E. L. Boasson (2015). Emergence of polycentric climate governance and its future prospects. *Nature Climate Change*.

Kahn, M. E. (2002). Demographic change and the demand for environmental regulation. *Journal of Policy Analysis and Management 21*(1), 45–62.

Kahn, M. E. and J. G. Matsusaka (1997). Demand for environmental goods: Evidence from voting patterns on California initiatives. *Journal of Law and Economics 40*(1), 137–174.

Kallbekken, S. and M. Aasen (2010). The demand for earmarking: Results from a focus group study. *Ecological Economics 69*(11), 2183–2190.

Kallbekken, S., S. Kroll, and T. L. Cherry (2011). Do you not like Pigou, or do you not understand him? Tax aversion and revenue recycling in the lab. *Journal of Environmental Economics and Management 62*(1), 53–64.

Kallbekken, S. and H. Sælen (2011). Public acceptance for environmental taxes: Self-interest, environmental and distributional concerns. *Energy Policy 39*(5), 2966–2973.

Kirchgassner, G. and F. Schneider (2003). On the political economy of environmental policy. *Public Choice 115*(3-4), 369–96.

Kriesi, H. (2005). *Direct democratic choice: the Swiss experience*. Lanham, Md.: Lexington, Books.

Longo, A., D. Hoyos, and A. Markandya (2012). Willingness to pay for ancillary benefits of climate change mitigation. *Environmental and Resource Economics 51*(1), 119–140.

Marcantonini, C. and A. D. Ellerman (2014). The implicit carbon price of renewable energy incentives in Germany. RSCAS Working Paper 2014/28, European University Institute.

Mathys, N. A. and J. de Melo (2011). Political economy aspects of climate change mitigation efforts. *The World Economy 34*(11), 1938–1954.

Metcalf, G. E. (2009). Designing a carbon tax to reduce U.S. greenhouse gas emissions. *Review of Environmental Economics and Policy 3*(1), 63–83.

Millner, A. and H. Ollivier (2015). Beliefs, politics, and environmental policy. Working Paper 20 3, Grantham Research Institute on Climate Change and the Environment, LSE.

Mohler, L. and D. Müller (2012). Substitution elasticities in Swiss manufacturing. Technical report, Bundesamt für Energie, Berne.

Murray, B. and N. Rivers (2015). British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy. *Energy Policy 86*, 674–683.

Nathani, C., D. Sutter, R. van Nieuwkoop, S. Kraner, and M. Peter (2011). Energiebezogene Differenzierung der Schweizerischen Input-Output-Tabelle. Technical report, Bundesamt für Energie, Berne.

Nemet, G. F. and E. Johnson (2010). Willingness to pay for climate policy: A review of estimates. SSRN Scholarly Paper ID 1626931, Social Science Research Network.

Oates, W. E. and P. R. Portney (2003). The political economy of environmental policy. In K.-G. M. a. J. R. Vincent (Ed.), *Handbook of Environmental Economics*, Volume 1 of *Environmental Degradation and Institutional Responses*, pp. 325–354. Elsevier.

Ostrom, E. (2009). A polycentric approach for coping with climate change. Policy Research Working Paper Series, The World Bank.

Rocchi, P., M. Serrano, and J. Roca (2014). The reform of the European energy tax directive: Exploring potential economic impacts in the EU27. *Energy Policy 75*, 341–353.

Sælen, H. and S. Kallbekken (2011). A choice experiment on fuel taxation and earmarking in Norway. *Ecological Economics 70*(11), 2181–2190.

Salka, W. M. (2001). Urban-rural conflict over environmental policy in the Western United States. *The American Review of Public Administration 31*(1), 33–48.

Sampei, Y. and M. Aoyagi-Usui (2009). Mass-media coverage, its influence on public awareness of climate-change issues, and implications for Japan's national campaign to reduce greenhouse gas emissions. *Global Environmental Change 19*(2), 203–212.

Spash, C. L. and A. Y. Lo (2012). Australia's carbon tax: A sheep in wolf's clothing? *The Economic and Labour Relations Review 23*(1), 67–85.

Stadelmann-Steffen, I. (2011). Citizens as veto players: Climate change policy and the constraints of direct democracy. *Environmental Politics 20*(4), 485–507.

Steg, L., L. Dreijerink, and W. Abrahamse (2006). Why are energy policies acceptable and effective? *Environment and Behavior 38*(1), 92–111.

Thalmann, P. (2004). The public acceptance of green taxes: 2 million voters express their opinion. *Public Choice 119*, 179–217.

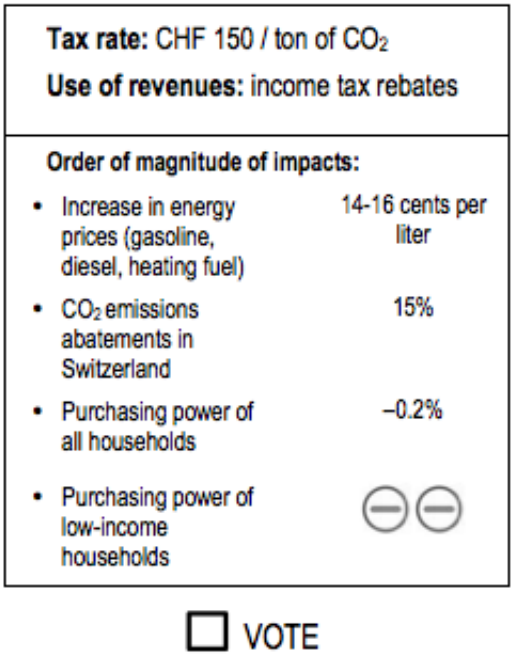
Vöhringer, F. (2012). Linking the Swiss Emissions Trading System with the EU ETS: Economic effects of regulatory design alternatives. *Swiss Journal of Economics and Statistics (SJES) 148*(II), 167–196.

World Bank (2014). State and trends of carbon pricing 2014. Technical report.

Appendix

A.1 Figures

FIGURE A.1: Example of a choice card



A.2 Tables

TABLE A.1: VOX data - Sample composition

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Gender (female)	0.526	0.5	0	1	1514
Age 18-29 (young)	0.117	0.321	0	1	1514
Age 30-59	0.532	0.499	0	1	1514
Age 60+ (elderly)	0.351	0.477	0	1	1514
German speaking	0.534	0.499	0	1	1514
French speaking	0.267	0.442	0	1	1514
Italian speaking	0.199	0.399	0	1	1514
Education (high school+)	0.616	0.486	0	1	1514
Number of cars in household	1.381	1.031	0	9	1514
Rural municipality	0.258	0.437	0	1	1514
Concern with unemployment	4.846	1.487	1	6	1488
Concern with income inequality	3.952	1.649	1	8	1489
Concern with public intervention	4.249	1.668	1	6	1444
Green affinity	0.063	0.243	0	1	1514

TABLE A.2: Choice experiment - Sample composition

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Socio-economic characteristics:					
Gender (male)	0.487	0.5	0	1	1200
Age	51.711	15.263	18	94	1200
National	0.897	0.305	0	1	1200
Education (years of)	15.341	2.072	11	18	1196
Household size	2.884	1.333	1	8	1200
Household annual income:					
<35'000 CHF	0.06	0.237	0	1	957
35'000-50'000 CHF	0.144	0.351	0	1	957
50'000-80'000 CHF	0.242	0.429	0	1	957
80'000-120'000 CHF	0.304	0.46	0	1	957
120'000-160'000 CHF	0.154	0.361	0	1	957
160'000-200'000 CHF	0.047	0.212	0	1	957
>200'000 CHF	0.049	0.216	0	1	957
Geographical location:					
German speaking	0.542	0.498	0	1	1200
French speaking	0.292	0.455	0	1	1200
Italian speaking	0.167	0.373	0	1	1200
Urban agglomeration	0.264	0.441	0	1	1200
Environmental attitudes:					
Main transport for commuting:					
Car	0.578	0.494	0	1	969
Bicycle	0.195	0.396	0	1	969
Bus	0.227	0.419	0	1	969
Concern for climate change:					
Very threatening	0.405	0.491	0	1	1189
Somewhat threatening	0.476	0.500	0	1	1189
Not threatening	0.119	0.324	0	1	1189
Preference for gradual carbon tax	0.635	0.482	0	1	1200

TABLE A.3: Swiss population - Socio-economic characteristics for comparison

Variable	**Mean**
Socio-economic characteristics:	
Gender (female)	0.505
Age 18-29 (young)	0.149
Age 30-59	0.448
Age 60+ (elderly)	0.234
National	0.757
Education (high school+)	0.521
Household size	2.25
Geographical location:	
German speaking	0.633
French speaking	0.227
Italian speaking	0.081
Rural municipality	0.17
Environmental attitudes:	
Votes to the Green Party	0.063
Votes to the Green Liberal Party	0.072

Source: All variables come from Swiss Statistics and concern the end of 2014. Election data concern the federal elections of 2015.

TABLE A.4: Choice experiments - Descriptive statistics

		Tax rate			
		60 CHF	90 CHF	120 CHF	150 CHF
Recycling	Income tax rebate	0.352	0.317	0.273	0.175
	VAT reduction	0.319	0.319	0.229	0.193
	Lump-sum redistribution	0.496	0.432	0.374	0.321
	Social cushioning	0.455	0.441	0.410	0.359
	Environmental recycling	0.350	0.295	0.215	0.148

TABLE A.5: Latent classes - Estimates from conditional logit

	Latent classes				
	(1)	(2)	(3)	(4)	(5)
Tax rate					
0 CHF (reference)					
60 CHF	-0.130***	0.326***	-0.314***	0.582***	0.0161
	(0.032)	(0.013)	(0.028)	(0.0110)	(0.026)
90 CHF	-0.099**	0.377***	-0.425***	0.432***	-0.167***
	(0.032)	(0.010)	(0.036)	(0.017)	(0.025)
120 CHF	-0.069*	0.379***	-0.387***	0.266***	-0.308***
	(0.023)	(0.011)	(0.033)	(0.019)	(0.028)
150 CHF	-0.119***	0.373***	-0.372***	0.126***	-0.463***
	(0.028)	(0.011)	(0.035)	(0.025)	(0.031)
Revenue recycling					
Income tax rebate (reference)					
VAT reduction	-0.0004	-0.009	-0.094*	0.038	0.002
	(0.030)	(0.008)	(0.044)	(0.021)	(0.029)
Lump-sum redistribution	0.552***	0.034***	-0.027	0.059**	0.125***
	(0.031)	(0.008)	(0.039)	(0.022)	(0.026)
Social cushioning	0.589***	0.051***	0.0095	0.054*	0.104***
	(0.0302)	(0.008)	(0.034)	(0.023)	(0.031)
Environmental recycling	-0.051	-0.018*	-0.067	0.019	0.063
	(0.038)	(0.009)	(0.042)	(0.020)	(0.033)
N	3861	8190	6564	4191	5334
Pseudo-R^2	0.3752	0.3523	0.8726	0.5399	0.1635

Note: Estimates report marginal effects from conditional logit. The dependent variable measures the acceptability of the proposed carbon tax designs. Robust standard error in parentheses.

* $p < 0.1$, ** $p < 0.05$, ***$p < 0.01$.

TABLE A.6: Latent classes - Membership estimates from multinomial logit

	(1) Latent class 1		(2) Latent class 2		(3) Latent class 3		(4) Latent class 4		(5) Latent class 5	
Socio-economic characteristics:										
Gender (male)	-0.025	(0.025)	0.058*	(0.035)	0.021	(0.031)	-0.034	(0.028)	-0.020	(0.028)
Age	0.0006	(0.001)	0.0004	(0.001)	-0.0008	(0.001)	-0.0001	(0.001)	-0.0001	(0.002)
National	0.017	(0.041)	-0.011	(0.053)	0.008	(0.049)	0.0154	(0.045)	-0.030	(0.040)
Education (years of)	-0.009	(0.007)	0.007	(0.009)	-0.002	(0.009)	0.0001	(0.007)	0.004	(0.008)
Household size	-0.004	(0.009)	0.012	(0.014)	-0.002	(0.012)	-0.004	(0.011)	-0.002	(0.011)
Household annual income:										
<35'000 CHF	-0.286**	(0.125)	0.297***	(0.112)	-0.069	(0.103)	-0.014	(0.097)	0.072	(0.099)
35'000-50'000 CHF	-0.142**	(0.068)	0.184*	(0.096)	-0.066	(0.077)	0.014	(0.073)	0.010	(0.085)
50'000-80'000 CHF	-0.061	(0.057)	0.135	(0.087)	-0.070	(0.068)	-0.022	(0.065)	0.018	(0.075)
80'000-120'000 CHF	-0.061	(0.051)	0.108	(0.083)	-0.119*	(0.064)	-0.005	(0.061)	0.077	(0.070)
120'000-160'000 CHF	-0.031	(0.055)	0.099	(0.087)	-0.090	(0.068)	0.034	(0.064)	-0.013	(0.076)
160'000-200'000 CHF	-0.055	(0.073)	0.117	(0.103)	-0.105	(0.088)	-0.041	(0.088)	0.084	(0.087)
>200'000 CHF										
Geographical location:										
French speaking	0.0332	(0.027)	-0.040	(0.036)	0.005	(0.034)	0.0005	(0.030)	0.001	(0.032)
Italian speaking	0.062*	(0.036)	-0.056	(0.050)	-0.056	(0.051)	-0.007	(0.041)	0.057	(0.042)
German speaking (reference)										
Urban agglomeration	0.002	(0.027)	0.032	(0.038)	-0.012	(0.036)	-0.021	(0.0314)	-0.002	(0.031)
Environmental attitudes:										
Main transport for commuting:										
Car	-0.027	(0.030)	-0.089**	(0.040)	-0.006	(0.038)	0.077**	(0.039)	0.045	(0.037)
Bicycle	0.009	(0.036)	-0.103**	(0.049)	-0.039	(0.049)	0.101**	(0.043)	0.032	(0.044)
Bus (reference)										
Concern for climate change:										
Very threatening	0.023	(0.050)	0.095*	(0.057)	-0.095*	(0.050)	0.041	(0.051)	-0.063	(0.044)
Somewhat threatening	0.083*	(0.048)	-0.0003	(0.057)	-0.037	(0.048)	0.052	(0.050)	-0.098**	(0.043)
Not threatening (reference)										
N	767									
Pseudo-R^2	0.0309									
Average class probabilities	0.7844		0.8588		0.9732		0.8110		0.9047	
Share of respondents	13.3%		29.2%		23.1%		15.3%		19.2%	

Note: Estimates report marginal effects. Robust standard error in parentheses. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$.

Average class probabilities and share of respondents obtained when identifying latent classes (AIC = 14427, BIC = 14741).

Annex 6

QUELLE EST L'UTILISATION PRÉFÉRÉE DE LA RECETTE D'UNE TAXE SUR L'ÉNERGIE?

Philippe Thalmann, EPFL, Lausanne, 30 mai 2016

Le 8 mars 2015, 2'010'326 électeurs suisses votaient contre l'initiative populaire fédérale « *Remplacer la taxe sur la valeur ajoutée par une taxe sur l'énergie* » alors que 175'405 (8%) votaient pour. Comme après chaque votation, un sondage VOX a été réalisé peu après cette votation par l'institut gfs Berne pour comprendre les motifs de vote. 1'514 personnes ont été interrogées par téléphone dans toute la Suisse entre le 9 et le 22 mars. Les principaux résultats de ce sondage ont été analysés par Kurer, Traber et Widmer (2016). La représentativité de l'échantillon a également été vérifiée par Schmidely et Thalmann (2016) et par Carattini et al. (2016). Ces derniers ont également estimé des modèles économétriques expliquant la décision de participer ou non au vote et la décision de voter pour ou contre l'initiative. Ces analyses utilisent les données communes à toutes les enquêtes VOX. Nous avons pu ajouter deux questions spécifiques, portant sur l'utilisation préférée de la recette d'une taxe sur l'énergie pour le cas où elle devait être introduite. En effet, utiliser cette recette pour remplacer la TVA n'est pas la seule possibilité. Kurer, Traber et Widmer (2016) montrent d'ailleurs que si l'initiative a été rejetée, ce n'est pas parce que les votants étaient opposés à une taxe sur l'énergie mais parce qu'ils ne voulaient pas qu'elle remplace la TVA: "Remplacer cette source de revenus importante et bien acceptée par un nouvel instrument dont on n'entrevoit que partiellement les conséquences fiscales a été considéré comme trop risqué par une grande majorité des votants." Carattini et al. (2016, tableau 4) confirment ce résultat: le désaccord avec l'argument du remplacement de la TVA est le deuxième facteur le plus important de rejet de l'initiative, talonnant de peu l'absence d'affinité avec l'un des deux partis écologistes, seuls soutiens de l'initiative.

Le but de cette note n'est pas de répéter les résultats des publications citées ci-dessus. Elle en présente d'autres, en réponse à ces questions:

1. Dans quelle mesure les arguments concernant l'affectation de la recette ont-ils contribué au rejet de l'initiative?
2. Quelles sont les affectations que proposent spontanément les sondés pour la recette d'une hypothétique taxe sur l'énergie?
3. Quelles sont les affectations que choisissent les sondés lorsqu'on leur suggère les types d'affectation classiques?
4. Comment se comparent leurs propositions spontanées d'affectation et leurs choix entre affectations suggérées?
5. Quelles sont les caractéristiques personnelles qui expliquent le choix d'une affectation suggérée plutôt qu'une autre?

1. IMPORTANCE DES ARGUMENTS POUR ET CONTRE L'INITIATIVE

Le sondage VOX a proposé aux sondés qui ont déclaré avoir participé à la votation trois arguments en faveur de l'initiative et trois arguments contre l'initiative, en se basant sur les débats lors de la campagne référendaire qui a précédé le vote populaire. Pour chaque argument, les sondés pouvaient exprimer leur accord sur une échelle de 1 (très d'accord) à 4 (pas du tout d'accord). Nous avons supprimé les réponses « *ne sais pas/refuse de répondre* », si bien que les effectifs sont différents pour chaque argument type. Ils restent cependant proches, si bien que les différences ne devraient pas fausser la comparaison des résultats.

Nous opérons une transformation des réponses pour faciliter la compréhension. En effet, on peut être opposé à l'initiative en étant d'accord avec les arguments contre ou pas d'accord avec les arguments en faveur de l'initiative. Pour comparer les degrés d'accord/désaccord et leur lien avec le refus de l'initiative, nous opérons trois transformations des réponses données:

1. Recoder les réponses pour qu'elles mesurent l'accord sur une échelle de 0 (pas du tout d'accord) à 1 (très d'accord) (formule: nouveau score = (4 – ancien score) / 3)
2. Reformuler les arguments pour que la majorité soit d'accord; donc un argument avec lequel la majorité n'a pas été d'accord est inversé
3. Classer les arguments par degré d'accord décroissant

Les résultats sont présentés dans le tableau 1.

Tableau 1 : Accord avec les arguments pour ou contre l'initiative

Argument	Moyenne	Effectif
La taxe sur l'énergie renchérit notablement la consommation énergétique et nuit ainsi à l'économie suisse	67.7%	906
Les recettes provenant de la taxe sur l'énergie ne compensent pas les pertes dues à la suppression de la TVA*	67.3%	854
En cas de repli de la consommation d'énergie, la taxe sur l'énergie devra continuellement être revue à la hausse pour prévenir toute perte fiscale	67.3%	850
La taxe sur l'énergie est injuste car les personnes démunies seront davantage lésées	64.3%	904
La taxe sur l'énergie ne réduit pas la dépendance de la Suisse vis-à-vis du pétrole, du gaz et de l'uranium étrangers*	55.0%	855
La taxe sur l'énergie incite à économiser l'énergie et à considérer des formes d'énergie renouvelables	54.7%	920

Les arguments dont le sens a été inversé pour correspondre à l'avis majoritaire sont marqués d'un astérisque

On voit que l'effet négatif sur l'économie est le principal argument contre l'initiative, suivi de très près de l'argument que la taxe sur l'énergie ne saurait remplacer la TVA en termes de recettes et de la crainte que la taxe sur l'énergie devrait continuellement être relevée pour maintenir les recettes. On voit bien ce qui est confirmé par les autres études citées en ouverture de cette note, à savoir que le manque de confiance dans la proposition de remplacer un impôt large et établi par un impôt étroit et neuf a particulièrement nui à l'initiative. Le seul

aspect de l'initiative perçu positivement par les sondés est l'incitation que donnerait la taxe à économiser l'énergie et à considérer les énergies renouvelables.

2. AFFECTATIONS PROPOSÉES POUR LA RECETTE D'UNE TAXE SUR L'ÉNERGIE

L'analyse ci-dessus a montré que l'utilisation de la recette est un aspect fondamental pour un projet de taxe environnementale. Utiliser la recette pour remplacer un autre impôt comme la TVA n'est clairement pas une option populaire. En prévision de ce résultat, le groupe du projet SEPIA avait fait ajouter dans le questionnaire du sondage VOX une question interrogeant les sondés sur l'affectation qu'ils souhaiteraient donner à la recette d'une hypothétique taxe sur l'énergie:

> « L'initiative populaire "Remplacer la TVA par une taxe sur l'énergie" prévoyait d'utiliser la recette fiscale de la taxe sur l'énergie pour remplacer celle de la TVA, mais on pourrait aussi utiliser la recette d'une taxe sur l'énergie autrement. Si une taxe sur l'énergie était introduite, comment faudrait-il utiliser sa recette fiscale à votre avis? »

Afin de faciliter leur interprétation, les réponses à cette question ouverte ont été regroupées en 11 types d'affectation. Certains correspondent aux 4 affectations suggérées dans la question fermée présentée plus bas, au moins après regroupement. D'autres sont des affectations dont nous n'avions pas anticipé la popularité, en particulier le financement de mesures de protection de l'environnement, soit la recherche d'un effet de renforcement plus large que seulement dans le domaine de l'énergie.

La tableau 2 montre les 11 types d'affectation regroupant les réponses à la question ouverte et, en regard lorsque c'est possible, les 4 options de la question fermée, avec les fréquences de choix de chaque affectation. Pour la question ouverte, les modalités "ne peut pas se décider ou ne sait pas" (32.7% des sondés) et "refuse de répondre" (9.3%) ont été ignorées, de même que les réponses à la question ouverte qui n'ont pas pu être associées à une (seule) des 11 types d'affectation (15.3%). Au total, il reste 646 réponses utilisables. C'est peu, mais nous verrons plus bas les préférences des sondés exclus ici.

Le tableau 2 montre qu'un sondé sur deux qui a proposé une affectation pour la taxe sur l'énergie a spontanément proposé de l'utiliser pour subventionner les énergies renouvelables. Lorsqu'on ajoute les propositions d'aider les ménages et les entreprises à augmenter leur efficacité énergétique, on trouve que près de deux sondés sur trois préfèrent une affectation cohérente avec le but de la taxe et capable de renforcer son effet incitatif. De plus, un sondé sur dix a proposé une affectation proche, pour des mesures de protection de l'environnement. Les sondés souhaitent donc surtout recycler les recettes dans le domaine de la taxe, conformément au résultat déjà obtenu notamment par Baranzini et Carattini (2016) et qu'ils expliquent principalement par la méconnaissance des effets incitatifs de la taxe.

Tableau 2 : Affectations proposées et choisies pour la recette d'une taxe sur l'énergie

Affectation proposée de manière spontanée (question ouverte)	**Fréquence** (%)	**Fréquence cumulée** (%)	**Affectation choisie parmi celles suggérées** (question fermée)	**Fréquence** (%)
Subventionner les énergies renouvelables	51.9	68.6	Subventionner les économies d'énergie et les énergies renouvelables	56.8
Aider les ménages à économiser l'énergie	10.7			
Aider les entreprises à économiser l'énergie	6.0			
Financer des mesures de protection de l'environnement	10.5	10.5		
Aider ménages pénalisés	9.6	10.7	Aider les personnes fortement pénalisées par la taxe	11.5
Aider les entreprises pénalisées	1.1			
Redistribuer l'argent aux ménages	3.9	3.9	Redistribuer l'argent aux ménages et aux entreprises	18.6
Redistribuer l'argent aux entreprises	0.0			
Abaisser un impôt existant	5.0	6.2	Abaisser ou supprimer un impôt existant	13.0
Supprimer un impôt existant	1.2			
Verser la recette dans la caisse de la Confédération ou du canton	0.2	0.2		

L'ordre des affectations dans la table respecte approximativement l'ordre décroissant des pourcentages tout en regroupant les affectations. L'effectif total est de 646 pour la question ouverte et 1273 pour la question fermée. "Fréquence cumulée" désigne la somme des fréquences par thème.

Bien que le sondage ait été mené dans les jours qui ont suivi la votation sur l'initiative populaire visant à remplacer la TVA par une taxe sur l'énergie, seul un sondé sur dix a pensé à ou choisi de proposer d'utiliser la recette de la taxe sur l'énergie pour abaisser ou remplacer un autre impôt. Cela démontre que la théorie d'une réforme fiscale écologique avec son deuxième dividende fiscal n'est pas connue, comprise ou partagée par les citoyens.

En Suisse, les débats sur les taxes d'incitation environnementale ont conduit à ce que leur recette soit généralement redistribuée intégralement à la population et aux entreprises. Une exception concerne la taxe CO_2 sur les combustibles, dont un tiers de la recette est utilisé pour promouvoir la réduction des émissions de CO_2 dans le domaine des bâtiments. Ces mesures de renforcement sont ainsi compatibles avec ce que deux sur trois de nos sondés ont choisi. Quoi qu'il en soit, seuls 4% environ des sondés qui ont proposé une affectation ont spontanément pensé à simplement redistribuer la recette de la taxe sur l'énergie aux ménages ou entreprises. Il faut reconnaître que la redistribution des recettes des taxes d'incitation n'est pas très connue dans le public, seul un quart des personnes sondées par INFRAS (2015, fig. 22) sachant que la recette de la taxe CO_2 était redistribuée. Notons enfin que l'amortissement social – venir en aide aux ménages et entreprises particulièrement affectés par la taxe – n'est pas non plus une affectation à laquelle beaucoup de sondés ont pensé.

3. AFFECTATIONS CHOISIES POUR LA RECETTE D'UNE TAXE SUR L'ÉNERGIE

Comme nous avions prévu que de nombreux sondés auraient de la peine à proposer une affectation pour la recette d'une hypothétique taxe sur l'énergie, nous avons fait ajouter dans le questionnaire du sondage VOX une deuxième question interrogeant les sondés sur leur affectation préférée, cette fois-ci en leur demandant de choisir entre quatre affectations suggérées:

> « Nous avons réuni quatre propositions d'affectation de la recette fiscale d'une taxe sur l'énergie. Veuillez indiquer laquelle vous préférez:
> a) subventionner les économies d'énergie et les énergies renouvelables
> b) aider les personnes fortement pénalisées par la taxe sur l'énergie
> c) abaisser ou supprimer un impôt existant
> d) redistribuer l'argent aux ménages et aux entreprises »

Les résultats pourraient changer lorsqu'on suggère des affectations aux sondés et qu'on les laisse choisir. Cela élimine d'une part quelques affectations, comme la protection de l'environnement en général, ce qui pourrait conduire certains sondés qui ont proposé une telle affectation à ne choisir aucune des affectations suggérées, mais ce n'est le cas que pour 3 sondés. Cela va aussi permettre aux sondés de penser à des affectations qui ne leur étaient peut-être pas venues à l'esprit et à modifier leur choix de l'affectation préférée. Cela va surtout inclure tous les sondés qui n'avaient pas pu ou voulu proposer une affectation.

Les réponses à la question fermée sont aussi présentées dans le tableau 2 ci-dessus. Notons qu'on perd 15.8% de sondés qui n'ont choisi aucune des options suggérées, mais il reste quand même deux fois plus de réponses que pour la question ouverte. Les fréquences dans la partie droite du tableau 2 représentent donc la répartition de 1'273 choix entre les quatre options suggérées.

La partie de droite du tableau 2 confirme essentiellement les préférences de la partie de gauche, en incluant deux fois plus de sondés. En effet, lorsqu'ils ont le choix entre une affectation qui renforce l'effet de la taxe, une affectation qui atténue son fardeau, une simple redistribution de la recette et une réforme fiscale écologique, presque six sondés sur dix choisissent le renforcement. Relevons cependant que la redistribution de la recette rencontre un succès beaucoup plus important que dans les propositions spontanées, ce qui montre que cette affectation peut convaincre, mais qu'on n'y pense pas de prime abord.

Les réponses à la question fermée peuvent être comparées à celles des quelques 1'000 personnes interrogées en ligne en 2014 par LINK pour INFRAS (2015). Le questionnaire leur demandait si la recette de la taxe CO_2 existantes (qui ne frappe que les combustibles, en particulier l'huile de chauffage) devait être utilisée selon chacune de six affectations possibles (Fig. 21):

1. Contributions au développement des énergies renouvelables (oui: 89%, non: 8%, ne sait pas: 3%)
2. Encouragement de technologies favorables à l'environnement (88%, 8%, 4%)

3. Subventions pour l'isolation thermique des bâtiments (78%, 17%, 5%)
4. Développement des transports publics (60%, 36%, 4%)
5. Création d'espaces naturels protégés (42%, 49%, 10%)
6. Redistribution uniforme à la population (20%, 75%, 6%)

La simple redistribution de la recette a été rejetée par trois sondés sur quatre alors que les mesures de renforcement ont été plébiscitées par 90% des sondés. Ces résultats sont tout à fait compatibles avec les nôtres, même s'il s'agit d'une taxe sur le CO_2 et non sur l'énergie. On notera en particulier le soutien très marqué pour la promotion des énergies renouvelables.

4. COMMENT L'AFFECTATION PRÉFÉRÉE CHANGE ENTRE QUESTION OUVERTE ET FERMÉE

En ayant invité les sondés à choisir entre quatre types d'affectation suggérées après leur avoir demandé de proposer spontanément une affectation, on a la possibilité de vérifier comment les préférences changent entre une question ouverte et une question fermée. On a aussi la possibilité de connaître les préférences de sondés qui n'ont pas répondu à la question ouverte. Les résultats sont résumés dans le tableau 3, pour les 1'273 sondés qui ont choisi l'une des quatre affectations suggérées dans la question fermée. Ils sont d'abord séparés entre trois groupes:

1. Les sondés qui n'ont pas du tout proposé d'affectation dans la question ouverte
2. Les sondés qui ont proposé une seule affectation qui correspond à l'une des quatre options de la question fermée (regroupement comme dans le tableau 2)
3. Les sondés qui ont proposé plusieurs affectations, ceux qui ont proposé une affectation qui n'a pas pu être attribuée à l'un des 11 types du tableau 2 et ceux qui ont proposé une affectation faisant partie des types "Financer des mesures de protection de l'environnement" ou "Verser la recette dans la caisse de la Confédération ou du canton"

Les choix du troisième groupe, trop hétérogène, ne seront pas détaillés. Dans le premier groupe, la répartition des choix est semblable à celle de l'ensemble des sondés (tableau 2), ce qui montre que ces sondés qui n'ont pas proposé d'affectation ont des préférences proches de celles des sondés qui en ont proposé une. En particulier, un sondé sur deux a choisi l'affectation qui renforce l'effet de la taxe sur l'énergie.

Le deuxième groupe compte 545 sondés qui ont proposé, dans la question ouverte, une affectation qui correspond à l'une des quatre affectations suggérées dans la question fermée et qui ont aussi choisi une de ces quatre affectations (32 sondés remplissent la première mais pas la deuxième condition). Dans leur cas, on peut vérifier s'ils modifient leur choix lorsqu'ils font face à un menu, donc lorsqu'on leur suggère des affectations. Le tableau 3 montre que c'est le cas pour un tiers environ de ce groupe. La réorientation la plus importante est d'une proposition d'affectation qui renforce l'effet de la taxe vers une redistribution simple (10.3%), mais il y a aussi des réorientations significatives dans d'autres sens. Parmi 12 réaffectations possibles (des quatre grands types proposés par les sondés dans la question ouverte vers les

trois options différentes qui leur ont été suggérées dans la question fermée), trois réaffectations ont été choisies par plus de 5% des sondés.

Tableau 3 : Comparaison des affectations proposées dans la question ouverte et choisies dans la question fermée

Affectation proposée (question ouverte)	**Affectation choisie** (question fermée)	**Nombre ou %**
Aucune		454
	Renforcer l'effet	47.8%
	Atténuer le fardeau	15.6%
	Redistribuer	20.5%
	Réforme fiscale	16.1%
Une affectation correspondant aux 4 types principaux		545
La même affectation préférée		63.3%
Renforcer l'effet	Redistribuer	10.3%
Atténuer le fardeau	Renforcer l'effet	6.1%
Renforcer l'effet	Réforme fiscale	5.3%
Les 9 autres redéfinitions de l'affectation préférée		15.0%
Plusieurs affectations ou une affection ne correspondant pas aux 4 types principaux		274

Répartition des 1273 réponses à la question fermée.
Les % sont calculés à l'intérieur de chaque catégorie.

5. ANALYSE CONJOINTE DES AFFECTATIONS

Une régression logistique multimodale permet d'identifier les déterminants personnels du choix entre les quatre affectations suggérées dans la question fermée. Une modalité de référence a été ajoutée pour les sondés n'ayant pas voulu choisir une affectation. Les résultats sont présentés dans le tableau 4.

Cette analyse met en évidence les résultats suivants quant à l'affectation préférée de la recette d'une taxe sur l'énergie, des résultats comparables à ceux de Thalmann (2004):

- Les personnes à niveau de formation plus élevé sont proportionnellement plus nombreuses à privilégier le renforcement des effets d'une taxe sur l'énergie par l'utilisation de sa recette pour subventionner les économies d'énergie et les énergies renouvelables.
- Les personnes à sensibilité politique de gauche tendent aussi à privilégier le renforcement des effets de la taxe sur l'énergie, mais se distinguent aussi des autres dans leur soutien à l'utilisation de la recette pour venir en aide aux personnes fortement pénalisées par la taxe.
- Les personnes âgées sont proportionnellement moins nombreuses à choisir trois des quatre affectations suggérées, ce qui revient soit à ne pas se prononcer soit à choisir l'abaissement ou la suppression d'un impôt existant. A noter que plusieurs réponses à la

question ouverte montrent que cette option a aussi été comprise comme le versement de la recette dans le fonds AVS.

- Les propriétaires de voitures soutiennent davantage que ceux qui n'en ont pas l'aide aux personnes fortement pénalisées, parmi lesquels ils pourraient se compter.
- Les germanophones soutiennent davantage que les francophones et les italophones la simple redistribution de la recette aux ménages et entreprises.

Tableau : Régression logistique multimodale des affectations préférées

Affectation choisie	Déterminant personnel	Valeur	Pr > Khi²	Stat. significatif
Subventionner les économies d'énergie et les énergies renouvelables	Constante	0.734	0.170	
	Niveau de formation (1 à 3)	0.370	0.021	**
	Affinité politique (1 à 10, gauche à droite)	-0.116	0.004	***
	Nombre de voitures du ménage	0.127	0.359	
	Catégorie de revenu (1 à 8)	0.097	0.141	
	Jeune (18-29 ans)	-0.011	0.974	
	Âgé (60+ ans)	-0.781	0.000	***
	Germanophone	0.260	0.222	
	Italophone	-0.318	0.295	
	Commune d'agglomération/campagne	-0.038	0.858	
Aider les personnes fortement pénalisées	Constante	-1.353	0.082	*
	Niveau de formation	0.170	0.467	
	Affinité politique	-0.124	0.032	**
	Nombre de voitures	0.403	0.025	**
	Revenu	0.135	0.124	
	Jeune	0.532	0.238	
	Âgé	-0.176	0.547	
	Germanophone	0.318	0.317	
	Italophone	0.478	0.245	
	Agglomération/campagne	-0.237	0.416	
Redistribuer l'argent aux ménages et aux entreprises	Constante	-1.064	0.131	
	Niveau de formation	-0.079	0.700	
	Affinité politique	-0.078	0.135	
	Nombre de voitures	0.223	0.185	
	Revenu	0.111	0.173	
	Jeune	-0.679	0.185	
	Âgé	-0.515	0.045	**
	Germanophone	1.079	0.001	***
	Italophone	0.733	0.077	*
	Agglomération/campagne	0.474	0.100	
Abaisser ou supprimer un impôt existant	Constante	-1.659	0.027	**
	Niveau de formation	0.195	0.377	
	Affinité politique	0.047	0.379	
	Nombre de voitures	0.074	0.687	
	Revenu	0.117	0.172	
	Jeune	0.112	0.805	
	Âgé	-0.533	0.051	*
	Germanophone	0.182	0.531	
	Italophone	0.038	0.925	
	Agglomération/campagne	0.362	0.226	

6. CONCLUSIONS

L'analyse de l'enquête VOX 118, en particulier des réponses aux deux questions que nous avons ajoutées, a conduit aux résultats principaux suivants:

- Tous les arguments contre l'initiative « *Remplacer la TVA par une taxe sur l'énergie* » ont contribué à sa défaite et aucun des arguments en sa faveur n'a vraiment été accepté.
- Lorsqu'on demande aux citoyens quelle est la meilleure façon d'utiliser le produit d'une taxe sur l'énergie, deux sur trois proposent spontanément des mesures de renforcement, à savoir la promotion des économies d'énergie et des énergies renouvelables.
- La redistribution simple, la compensation sociale et la réforme fiscale écologique se partagent à parts environ égales les propositions restantes.
- Lorsqu'on leur demande de choisir entre ces types d'affectation, deux fois plus de sondés répondent que lorsqu'on leur demande de proposer spontanément une affectation.
- Les choix entre affectations suggérées sont semblables aux propositions spontanées, avec un léger glissement toutefois en faveur de la redistribution simple, une option appréciée par un sondé sur cinq environ même s'il n'y pense pas spontanément.
- Les citoyens au bénéfice d'une meilleure formation ou avec une sensibilité de gauche soutiennent particulièrement les mesures de renforcement.
- La redistribution simple est un peu mieux acceptée en Suisse alémanique.
- La compensation sociale est un peu plus favorisée par les électeurs à sensibilité de gauche et les propriétaires de voitures.

Cette analyse de l'enquête VOX qui a suivi la votation du 8 mars 2015 sur l'initiative populaire fédérale « *Remplacer la taxe sur la valeur ajoutée par une taxe sur l'énergie* » confirme ce que plusieurs autres enquêtes ont montré: la majorité des électeurs souhaite utiliser la recette d'une taxe environnementale pour renforcer son effet ou, ce qui revient au même, pour aider les ménages et entreprises à réduire leur exposition à la taxe en réduisant l'activité taxée (par exemple subventions pour l'augmentation de l'efficacité énergétique). Que ce soit pour une taxe sur l'énergie ou sur le CO_2, la promotion des énergies renouvelables est très populaire. Ce résultat est en contradiction complète avec le projet du Parlement fédéral de supprimer les subventions à l'efficacité énergétique et aux énergies renouvelables dans une dizaine d'années pour ne miser plus que sur des taxes incitatives, dont la recette serait intégralement redistribuée aux ménages et entreprises (projet de système incitatif en matière climatique et énergétique – SICE – mis en consultation par le Conseil fédéral en mars 2015). Il faudra donc un grand travail d'information et de persuasion pour faire accepter, par le peuple et les cantons, la modification constitutionnelle prévue.

L'information des sondés est un élément important de ce type de sondage. On l'a déjà vu en comparant les réponses à la question ouverte et à la question fermée sur l'affectation préférée de la recette d'une taxe sur l'énergie. On le voit aussi dans l'analyse de Carattini et al. (2016), qui compare ces réponses avec les choix d'un échantillon similaire de sondés entre "paquets"

constitués d'un niveau de taxe CO_2 et d'un mode de recyclage de la recette avec indication des effets économiques et environnementaux de chaque "paquet". Ce sondage montre que les sondés sont bien moins favorables à utiliser la recette de la taxe environnementale pour renforcer son effet incitatif et plus favorables à une redistribution simple aux ménages lorsqu'on leur rappelle que la taxe frappant les énergies "sales" favorise déjà en soi les énergies "propres" et l'efficacité énergétique et que la redistribution forfaitaire privilégie (en termes relatifs) les ménages à faibles revenus.

7. RÉFÉRENCES

Baranzini, Andrea, et Stefano Carattini: “Effectiveness, earmarking and labeling: testing the acceptability of carbon taxes with survey data”, Environmental Economics and Policy Studies, 2016 (DOI 10.1007/s10018-016-0144-7).

Carattini, Stefano, Andrea Baranzini, Philippe Thalmann, Frédéric Varone, et Frank Vöhringer, "Green taxes in a post-Paris world: are millions of nays inevitable?", mimeo, Genève, May 2016.

INFRAS, Klimaschutz und Grüne Wirtschaft – was meint die Bevölkerung? Ergebnisse einer repräsentativen Bevölkerungsbefragung. Schlussbericht. Bundesamt für Umwelt. Zürich, 2015.

Kurer, Thomas, Denise Traber et Thomas Widmer, "VOX118 - Analyse de la votation fédérale du 8 mars 2015", gfs Bern, 2016.

Schmidely, Loïc, et Philippe Thalmann, "Analyse des résultats du sondage VOX – remplacer la TVA par un impôt sur l’énergie", miméo, EPFL, 2016.

Thalmann, Philippe, "The public acceptance of green taxes: 2 million voters express their opinion", Public Choice, 119(1-2), 179-217, April 2004 (DOI: 10.1023/B:PUCH.0000024165.18082.db).

Remerciements

Cette recherche a bénéficié du soutien de l'Office fédéral de l'énergie dans le cadre du projet SEPIA Social Cushioning of Energy Price Increases and Public Acceptability, contrat N° SI/500806-01. L'auteur remercie ses partenaires dans le projet – Andrea Baranzini, Stefano Carattini, Frédéric Varone et Frank Vöhringer – pour leur aide dans la préparation des questions VOX et leurs commentaires et suggestions sur le texte, ainsi que Loïc Schmidely pour la préparation des données et l'analyse statistique dans la section 5.

Annex 7: Household statistics by family composition

	NoKids1	NoKids2	NoKids3	NoKids4	NoKids5	Kids1	Kids2	Kids3	Kids4	Kids5	Retired1	Retired2	Retired3	Retired4	Retired5
Households	180'223	279'988	366'224	454'963	517'725	189'683	199'784	159'518	101'676	69'793	295'698	185'668	139'871	108'478	77'870
Total persons	2.02	2.00	1.86	1.83	1.77	4.11	3.92	3.64	3.69	3.61	1.47	1.53	1.61	1.52	1.61
Children	0.00	0.00	0.00	0.00	0.00	1.81	1.66	1.53	1.58	1.55	0.03	0.01	0.01	0.00	0.00
Adults	2.02	2.00	1.86	1.83	1.77	2.30	2.26	2.11	2.11	2.06	1.44	1.52	1.60	1.52	1.60
Equivalent persons[1]	1.51	1.50	1.43	1.42	1.39	2.23	2.15	2.03	2.05	2.01	1.23	1.26	1.30	1.26	1.30
Income	4'405	6'731	8'284	10'401	16'255	6'682	9'327	11'184	14'311	22'896	3'638	5'320	6'950	8'535	14'962
Inc. per equiv. person	2'915	4'485	5'795	7'342	11'736	2'997	4'342	5'502	6'979	11'378	2'956	4'217	5'331	6'787	11'490
Income per capita	2'179	3'362	4'457	5'673	9'183	1'628	2'381	3'076	3'877	6'345	2'475	3'487	4'318	5'633	9'320
Composition with regard to taxation:															
Couple, no kids	1.00	1.00	0.86	0.83	0.77	0.10	0.17	0.23	0.21	0.23	0.43	0.52	0.60	0.52	0.60
Couple, two kids	0.00	0.00	0.00	0.00	0.00	0.90	0.83	0.77	0.79	0.77	0.01	0.00	0.00	0.00	0.00
Single	0.00	0.00	0.14	0.17	0.23	0.00	0.00	0.00	0.00	0.00	0.56	0.48	0.40	0.48	0.40

Source: Ecoplan 2012a.

[1] Equivalent persons are calculated according to OECD equivalence scale: The first household member is counted as 1, while all subsequent adults count 0.7 and children 0.5 towards the equivalent persons measure.

Annex 8: Household statistics by place of residence

	City1	City2	City3	City4	City5	Agglo1	Agglo2	Agglo3	Agglo4	Agglo5	Peri1	Peri2	Peri3	Peri4	Peri5
Households	194'650	194'693	201'544	194'360	216'231	259'593	273'857	294'362	316'652	336'571	211'361	196'891	169'707	154'105	112'586
Total persons	2.17	2.14	2.00	1.87	1.81	2.36	2.46	2.31	2.13	2.03	2.57	2.71	2.37	2.19	1.96
Children	0.44	0.36	0.29	0.20	0.11	0.53	0.52	0.41	0.25	0.21	0.61	0.60	0.39	0.28	0.13
Adults	1.73	1.78	1.71	1.67	1.69	1.83	1.94	1.90	1.88	1.82	1.96	2.11	1.98	1.91	1.83
Equivalent persons	1.51	1.50	1.45	1.40	1.38	1.58	1.63	1.58	1.52	1.48	1.68	1.74	1.61	1.54	1.45
Income	4'331	6'537	8'032	9'928	15'385	4'781	7'087	8'866	10'954	17'694	4'982	7'731	9'200	11'127	16'846
Inc. per equiv. person	2'868	4'350	5'550	7'108	11'134	3'021	4'337	5'620	7'225	11'995	2'972	4'432	5'697	7'207	11'588
Income per capita	1'995	3'050	4'007	5'315	8'507	2'027	2'876	3'843	5'154	8'734	1'940	2'850	3'877	5'077	8'604
Composition with regard to taxation:															
Couple, no kids	0.52	0.60	0.57	0.57	0.64	0.57	0.68	0.69	0.75	0.72	0.66	0.70	0.79	0.77	0.77
Couple, two kids	0.22	0.18	0.15	0.10	0.06	0.26	0.26	0.20	0.12	0.10	0.30	0.30	0.19	0.14	0.06
Single	0.27	0.22	0.29	0.33	0.31	0.17	0.06	0.10	0.12	0.18	0.04	0.00	0.02	0.09	0.17

Source: Ecoplan 2012a.