Chapter 8

Differentiated or Uniform International Carbon Taxes: Theoretical Evidences and Procedural Constraints

Jean-Charles Hourcade
Laurent Gilotte

8.1 Introduction

From the late 1980s to 1996, debates on economic incentives aiming at curbing greenhouse gas emissions focused on a uniform international carbon tax. There are many historical reasons why attempts to coordinate climate policies through price signal failed and why coordination through quantitative emission limits was adopted at CPO3 (3rd Conference of the Parties, Kyoto 1997). The latter framework, however, is not firmly established as long as the following question is unresolved: which rules should be adopted for the distribution of primary rights to developing countries? If no politically acceptable rule can be found, the negotiation agenda may see the return of coordination through prices or some hybrid system. This paper aims at shedding light on the difficulties inherent to the price approach, some of which in fact are comparable with those impinging on quota-based coordination. Relying on a theoretical model that captures the key practical aspects of climate policies, this chapter demonstrates that an efficient allocation is achieved by differentiated taxes. Beyond existing uneven distribution of income, this is due to country-specific side effects of a carbon tax and specifics of development patterns. A uniform tax would be appropriate only if applied together with transfers between coun-

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tries. Considering the difficulty of negotiating such transfers, a uniform carbon tax would require each country be persuaded that this tax is welfare improving, thanks to the positive side-effects of removing existing distortionary taxes and to negative costs potentials. Beyond this short-term perspective, we point out the necessity of differential treatment (taxes on emissions from industry could be harmonized and taxes on households and transportation sector differentiated) to reconcile the objective of achieving equal marginal costs in welfare across nations and the necessity of nondistorting competition on international markets.

The insights provided by the toolbox of economists are obscured by the differences, often neglected in policy debates, between a first-best solution and solutions accounting for political constraints hinging on the negotiation process: sovereignty principle, subsidiarity principle (in the European Union), political judgments about the social acceptability of measures, loose and unstable perceptions of self-interests, and influence of intellectual traditions.[1]

The professional reflex of economists is to distinguish as clearly as possible these two levels of analysis, leaving to the policymaker the task of minimizing the gap between the first-best and second-best solutions. However, when this gap is too important, experience demonstrates that policymakers ultimately tend to disregard the results of economic analysis and to prioritize considerations of "procedural efficiency" such as the political acceptability and the simplicity of enforcement and monitoring of given policies.[2] To avoid this distrust in the case of climate policies, economists should consider the procedural constraints and transaction costs of specific policies at the outset of their analysis; however, symmetrically policymakers should also note that many counterintuitive conclusions of theoretical analysis helps us to understand why the expected procedural efficiency of some policy packages might not be realized.

The interest of this double requirement can be illustrated in the case of debates about internationally harmonized carbon taxes. Such a perspective was officially supported by the European Commission before the 1992 Earth Summit in Rio de Janeiro and was discussed further in the European Union after the Essen summit in December 1994.

The main rationale for this proposal is indeed procedural in nature and relies

[1]This is, for example, the case for the incentive systems: European countries accept seemingly the perspective of carbon taxes more easily than the United States and are reluctant to consider tradable emission permit systems

[2]This is one of the reasons why the overwhelming majority of environmental policies rely on so-called noneconomic instruments, such as regulation and standards, when economic literature advocates for economic instruments in the form of Pigouvian taxes or tradable pollution permits.

on a political intuition. Noting from economics that Pigovian taxes or tradable permit systems lead to the same optimum, the defenders of an international carbon tax call attention to the difficulties that an international tradable emission permits system (ITEPS) would confront: the capacity of the regulatory authority to impose sanctions, the disagreements about the currency to be traded (only carbon dioxide [CO_2] or all greenhouse gas sources and sinks counted in terms of CO_2 equivalent), or the risks of monopolization of the market by oil producers. However, the Gordian knot of the system is obviously the agreement on the initial allocation of permits. First, each of the possible criteria for this allocation (grandfathering, egalitarian, and a two-tiered approach)[3] might be unacceptable to a significant number of negotiating parties. Second, decisions on the initial allocation and on the definition of the traded currency are not independent of each other. The scope of the system and the global warming potentials of different gases used to aggregate emissions change countries that would be net payers and net receivers in an ITEPS.[4]

A uniform carbon tax is meant to provide a clear economic signal that would not distort international industrial competition and that could be implemented without excessive administrative costs. Moreover, despite the fact that a significant part of the literature examines tax systems whose product is internationally redistributed, political constraints on the acceptability of the system (e.g., sovereignty principle, reluctance to accept such transfers in the name of very long run issues, and monitoring the use of funds) explain why all the official proposals to date assume that these taxes should be internationally coordinated but that their revenue would be internally recycled in each country.

Our purpose here is not to refute the interest of uniform international carbon taxes but to show why its procedural efficiency is not so evident as it seems intuitively. It could indeed be deeply undermined by the equity-efficiency dilemma even if it does not confront it as directly as in the case of property rights assignment on atmosphere.

The basic reason is the well-established result that it is not easy in practice to separate efficiency from distribution when goods are public. This is the framework for climate policies simply because of the physical fact that GHG atmospheric concentration is the same for all of us independently of our level of income and our level of concern for climate change. The policy implications of this point for income distribution have been to date developed by Chichilnisky [3] and Chichilnisky and Heal [4].

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[3] On this topic, see OECD [21].

[4] This was illustrated by the controversy between Anyl Agarwal and the World Resources Institute about the role of the CH_4 and deforestation in the ranking of GHGs emitters.

We develop a theoretical framework capturing other reasons why uniform carbon taxes are, in the general case, suboptimal if not accompanied by lump-sum transfers among countries. We focus on the concept of abatement technology and on the difficulties stemming from the concept of "double dividend" yielded by the recycling of the revenues of a carbon tax; in a further step, coming back to procedural efficiency, we point out some paradoxes likely to be involved in the international negotiation of a carbon tax.

8.2 Climate Policies and Limits of First-best Framework

Beyond the appeal of "procedural efficiency," a second reason that the focus has been so easily placed on a uniform tax is that this solution corresponds to a widely held view among environmental economists. In a Pigovian perspective a tax gives to every agent the same "signal" about the potential costs of climate change. Conventionally, it is then assumed to allow for an optimal allocation of abatement efforts because agents will adopt only the GHG abatement techniques whose marginal cost is lower than the tax level. However, this allocative efficiency of a uniform carbon tax can be questioned because of the specifics of the climate change issue.

8.2.1 Climate as a Public Good: Theoretical Backgrounds of a Recent Controversy — A first criticism of tax uniformity stems from the heterogeneity of existing fiscal systems. From a basic demonstration relying on the Harberger triangle, it can be shown that a uniform tax would place a bigger burden on those countries whose preexisting energy taxation levels are high (Hoeller and Coppel [12]).

A formal solution to this problem has been sought in public finance theory: When a tax aims at internalizing an externality and at levying funds for government's budget, the optimal tax structure should be additive. The externality-creating commodity should be subjected to a tax which is a weighted average of two terms—one "fiscal" and the other equal to the marginal social damage, as in Pigovian taxation (Sandmo [21]).[5] "Therefore, there is no reason to try to achieve equality of the total fiscal burden on fossil fuels in different countries. On the other hand, there are grounds to seek agreement on the amount of the reference internalizing tax" (Coppel [5]). A uniform carbon tax could be simply added to fiscal systems previously restructured according to Sandmo's rule.

[5] A summary of this discussion can be found in Godard [9].

Even without considering the implementation difficulties and transaction costs associated with this solution, its fundamental caveat comes from the fact that Sandmo's framework assumes that individuals face the same prices and taxes. In contrast to this, the point made by Hoeller and Coppel [12] derives directly from the fact that countries have different consumer prices, partly as a consequence of their individual fiscal systems. With another approach, emphasizing the consequences of differences in income levels (with subsequent heterogeneous preferences) and of uneven access to technology, Chichilnisky [3] demonstrated that, in the case of climate policies, a uniform internalizing tax would lead to a suboptimal equilibrium if there are no lump-sum transfers among countries.

Chichilnisky's argument surprised many economists; Bohm [2] recalled that trade among nations allows for optimality of uniform taxation despite differences in utilities. The rationale for such a solution is the following: If international markets are assumed to ultimately give each country access to the same technology basket (either directly or by assuming a free access to the goods produced by the best available techniques), the technology mix apt to minimize the overall cost of meeting a given abatement target will be implemented only if the same price signal, equal to the marginal abatement cost, is given to each agent. This view prioritizes the launching of a clear signal so as to optimize the technology mix. Nevertheless, Bohm's model implicitly resorts to lump-sum transfers so as to equalize the marginal utility of income among countries. This result is confirmed by Chichilnisky and Heal [4] who, in a model allowing for the transfers of goods between countries (lump-sum transfers), state that "if we make the transfers that are needed to solve this problem, it will be then efficient to equate marginal abatement costs" (i.e., to equate carbon taxes). They also point out (p. 447) that a model allowing lump-sum transfers "is not a model of international trade, which would require the imposition of balance of trade constraints."

In the specific case of climate policies, it can be argued that a uniform tax would be an optimal solution only under very exceptional conditions. The systematic demonstration can be derived from a very general model with a private good generating externalities written by Laffont [18, pp, 75ff.]. Interestingly for the current discussion, he points out a special type of externality that could encompass climate change issues: In the case of "nonpersonal externalities," it can be shown that first-best (Bowen-Lindahl-Samuelson conditions) is achieved through a uniform Pigovian tax and lump-sum transfers (the net amount of the transfers being equal to the total revenue of the tax). Each Pareto-optimal level of emission is jointly determined with a uniform tax and a set of lump-sum transfers.

In the case of a compensation mechanism accompanying an international carbon tax, there is little chance that countries will share their tax receipts so as to achieve an allocation of income that enables an optimal emission level corresponding to the tax. This prevents a uniform taxation from being automatically optimal. There is indeed no reason that the necessary transfers will be acceptable, and thus that optimal emission level will be achieved. Intuition suggests on the contrary that this is true only for abatement targets and corresponding tax which do not imply too-large transfers. For a given distribution of income and in a perfect information context, any first-best solution that leads to welfare gains for every country is potentially acceptable, whatever the necessary initial transfers. But in practice, because of the informational and procedural constraints, the scope for negotiable first-best solutions is much narrower and perhaps void.

This doubt about the likelihood of international transfers restoring systematically the optimality of a uniform carbon tax is obviously strengthened if one considers the implementation difficulties and transaction costs of such a solution. This leads us to investigate further the meaning and the relevance of the heterogeneity hypothesis about both preferences and production functions of the GHG emissions abatement that underpin the plea for differentiated taxations.

We do not come back in the rest of this text to the inequality of the wealth distribution as a sufficient reason for differentiated taxes if appropriate compensations are not given to offset the recessive impacts of a uniform tax. This result is well established by Chichilnisky and Heal, but the level of abstraction of the abatement production function of their model might obscure the fact that, if one considers seriously the determinants of emission trends, their line of argument stands even in a world with equal income distribution levels and a free trade ensuring equal access to the best available abatement techniques and to the composite goods produced at the lowest cost. The crux of the matter is the linkages between the content of the production functions of GHG abatement and the reasons for heterogeneous preferences for energy.

8.2.2 Specifics of Climate Issues and Policies — Even in a perfect world market economy, the transformation frontier between GHG abatement and other goods and services never is the same for all countries. The first-best solution by which the best available techniques can be implemented by each country or by which, in the case of nontransferable techniques,[6] international

[6]Natural comparative advantages resulting, for example, from the specifics of the geographic context, such as the endowments in hydropotentials.

trade gives each country access to the goods at the same price (equal to its marginal production costs) comes to a centrally planned abatement program mobilizing a unique set of techniques ranked by decreasing returns. The existence of barriers in technology markets would not be, per se, an argument against a uniform tax but a reason to take up transitory measures aimed at removing market imperfections.[7]

Note that, in this framing, the production frontier governing the transformation rate between GHG abatement and other goods and services results strictly from a given set of techniques defined in a pure engineer's sense; the abatement costs curve is calculated as the arithmetic sum of technical costs. This framing stops being relevant when one accounts for two specifics of the debates about greenhouse policies: (1) In the energy field, the very definition of an abatement technique is less trivial than it seems because of the fact that the ranking of technical solutions by decreasing cost-effectiveness is very conditional on assessing the cost of delivering a given physical quantity of final energy or assessing the cost of providing a given set of end-use services, and (2) there are critical debates about possible economic double dividends (or extra macroeconomic costs) of climate policies and about the magnitude of a wedge between their gross and net costs.[8]

Heterogeneity of Utilities and Abatement Costs

As professional economists, our first reflex is to frame a public policy problem in a way that separates agents' utilities on the one hand and technical abatement costs on the other. However, in the case of the greenhouse issue, this separation is not as easy as it seems at first glance, for reasons that are easy to illuminate in the case of energy systems.

From the mid-1970s on, "bottom-up" specialists in the energy field helped us understand that substitution elasticities between other goods and final energy described by current statistics might be a misleading indicator of the driving forces behind energy demand. This argument was basically used to point out efficiency gaps along the transformation chain between primary energy, final energy, and end-use energy services. The heated energy policy debates with "top-down" specialists about the meaning and magnitude of these effi-

[7]This view neglects possible obstacles to technology appropriation pointed out by literature on appropriate technology; these are not, stricto sensu, due to imperfections in international markets but to parameters, such as prevailing institutions, technical capabilities, and cultural habits, which make the hidden costs of using a given technology different in various countries.

[8]For a taxonomy of costs concepts in use in debates about climate policies, see chapter 8 of working group III of the Ipcc report (Hourcade, Richels, Robinson 1995).

ciency gaps[9] masked a very important theoretical implication of this move in energy demand analysis. It is uncontestable that, theoretically, neither final energy demand nor energy services should be included in the consumer's utility function. They are ancillary services of components of this function, such as transportation, thermic comfort, or food conservation. In this sense there is never a substitution between energy and other goods in the individual preference function (e.g., between a fried egg and the energy needed to cook it) but between energy-intensive and non-energy-intensive products and services and between energy-intensive and non-energy-intensive ways of making them.

This forces us to question the definition of GHG abatement techniques and of revealed preferences in models, including energy in the welfare function, and paves the way for an argument in favor of differentiated taxes even in a world without income inequalities. In current energy demand functions, the apparent substitution elasticity between energy and other goods should not be interpreted as a measurement of the "pure preference" for energy. In the case of a high energy price increase, for example, a medium town with a tramway network could switch rather quickly to less energy intensive transport systems (combining tramway and bicycle) when a town typically built for cars, such as Los Angeles, would simply not be able to do so over the same time period. Even if the citizens of the two cities had the same degree of concern for climate change, the revealed willingness to substitute non-energy-intensive goods and services to gasoline will simply be higher in the first one.

If we stand within this framework (substitution between energy and a composite good), it follows that the observed preference functions differ across countries for reasons other than differences in income and "pure" preference for precaution toward climate risks. A more appropriate theoretical framework would obviously be to treat urban structures and transportation modes as technical endowments. The Appendix gives a very tentative formalization of this issue with a world composed of agents with identical utility functions, including a composite good, leisure activities, and thermal conditioning (heating or cooling), but living in national contexts whose features (manmade or natural features do not matter at this stage of analysis) demand different quantities of energy and transportation for achieving the same level of welfare.

The critical policy implication comes from the fact that, contrary to energy-efficient technologies that can be adopted at the margin of a system, urban and transportation systems constitute technical systems in the Gille [8] sense with their internal systemic coherence. The perfect international market hypothesis

[9] A very useful clarification of this debate can be found in Jaffe and Stavins [16].

is then inapt for solving the problem of the heterogeneity of abatement costs because these "technologies" are not importable goods: Los Angeles cannot "import" an "urban structure technology" even over the middle term. Then, because abatement costs do not depend only on technical answers in the engineering sense (costs of switching from coal to gas or nuclear in electricity generation or costs of more efficient boilers), the production function of GHG abatement cannot be homogeneous and is inherently country specific.

Double-Dividend of Tax Recycling and Macroeconomic Production Function of GHG Abatement

For defining the content of the production function of GHG abatement, another source of complication is the fact that, given the amount of uncertainties surrounding climate change, policy debates were underpinned by the search for so-called no-regret policies, namely, for policies entailing no net incremental cost and that will not be regretted if, ultimately, anthropogenic climate change is proved to be harmless.

The no-regret concept results from a pure strategic intuition and has no rigorous definition. It will suffice, for the following discussion, to note that if the current state of economy is assumed to be optimal, an improvement of environmental quality is possible only through a reduction of production of conventional goods. A no-regret climate strategy is possible only if this economy is located somewhere below the theoretical production frontier describing the maximum of production of conventional goods for a given quality of environment and if the policy choice enables the progress toward the production frontier in order to reduce GHG emissions.[10]

Initially centered on the "efficiency gap" and possible negative costs measures, discussions about "no-regret" were extended to the environmental double dividend expected from the side effect of GHG reductions on other environmental issues (e.g., acid rain, tropospheric ozone, and urban congestion) and, with more heated disputes, from the economic double dividend of recycling the revenue of carbon taxes.

A tax on CO_2 emissions is indeed meant to be an incentive to foster the use of carbon saving technics and not a financial source for supporting research on energy efficiency or supplying a world fund, such as the Global Environment Facility. This tax should be high enough to have an effect on consumption and

[10]An overview of this debate can be found in chapters 8 and 9 of the forthcoming IPCC report (Hourcade, Richels, and Robinson [15]).

production choices, and this poses critically the question of how its revenue is recycled.

The side effects of an internally recycled ecotax[11] were analyzed in great detail by some empirical macroeconomic studies, mainly in the European context, that concluded positively about a double dividend. This was the case in the Quest simulations by the European Commission as well as in national studies in countries such as Germany (Walz et al. [22]), France (Godard and Beaumais [10]), and the United Kingdom (Barker [1]). Works from a theoretical perspective shed some doubts on the likelihood of such a double dividend being apt to offset the gross costs of climate policies if all the general equilibrium effects of such a fiscal reform are accounted for. This is not the place to enter into the details of this discussion but it is noncontroversial that a double dividend occurs when the marginal distortionary effect of a carbon tax (or ecotax) is lower than the distortionary effect of taxes for which it is substituted.

This introduces a second element of heterogeneity between countries' cost functions: Tax impacts are the net result of the costs of increasing energy prices and of the benefit from removing more onerous taxes, and both these parameters are mostly country specific. Many European countries, for example, finance not only their public administration but also their health system, social security, and teaching system by raising funds from taxes levied directly or indirectly on wages; this wedge between the labor cost and the net wages might be a cause of structural unemployment. The fiscal system is very different in the United States and Japan as a practical translation of different views of social organization.[12] In the same way, the measurement of the distortionary effects of preexisting energy taxes cannot be directly derived from their observed level, as many oil-importing countries levy energy taxes to achieve public objectives, such as security, minimization of shocks of trade balance, and funding of road infrastructure.

What matters here is that the direct costs of abatement are not the only costs a government must face. The recycling of a carbon tax creates a wedge between the gross cost of GHG abatement (the sum of the costs of abatement technology) and the net cost for the economy; determinants of this wedge are country specific and are not apt to be homogenized through foreign trade[13] across countries because the double dividends are intangible.

[11] Note that ecotaxes other than carbon tax have been studied (e.g., the carbon energy tax in Europe).

[12] On the difference between U.S. and European contexts, see Krugman [17].

[13] These components characterize a second-best world and would not play a role any more if fiscal distortions were removed in all countries prior to climate policies and if the rules for interpreting preexisting energy taxes were the same in all countries. These preconditions will be hardly fulfilled prior to the forthcoming negotiation steps.

8.3 Two Tentative Models

These features of the international negotiation over a carbon tax can be illustrated with two versions of the same generic model.

8.3.1 A One-Energy Model — Let us assume an economy with two goods available: Q, the composite good, and F, fossil energy. Each country is represented with (1) a utility function $U_i = U_i(Q_i; F_i; G)$, G being a public externality, or the GHG emissions, with $UG < 0$, and (2) an income level R_i.

The planner aims at choosing a tax set (t_i) on fossil fuel consumptions (F_i) that maximizes the aggregate welfare function. Because of the procedural constraints stated earlier, he is not allowed to make lump-sum transfers between countries. But he gives each country a compensation as large as the tax revenue he collects in the country. The planner announces to the countries the individual taxes (t_i) and the level of externality G they will face, as well as the level of compensations (C_i) they will receive.

Each country maximizes its utility choosing its demands for Q and F. It does not account for the externality it produces itself. The budget constraints are

$$R_i \geq Q_i + \pi_F(t_i)F_i \quad \text{with } \pi_F = (p_F + t_i) \quad \text{and} \quad R_i = R_i^o + C_i.$$

We write the demand functions in Q and F as

$$q_i(\pi_F(t_i); R_i; G) \quad \text{and} \quad f_i(\pi_F(t_i); R_i; G)$$

and the indirect utility functions as

$$V_i(\pi_F(t_i); R_i; G).$$

The planner must satisfy two constraints. First, the emission level (by approximation the sum of fossil fuels consumption), resulting from the individual countries' optimization, should not exceed the level chosen by the planner (denoted G). Second, the compensation (denoted C_i) granted to a country should not exceed the tax receipts in this country. His maximization program is

$$\max_{t;C;G} \sum_{i=1}^{n} \alpha_i \cdot V_i(\pi_F(t_i); R_i; G)$$

with constraints

$$\sum_{i=1}^{n} f_i(\pi_F(t_i); R_i; G) - G \leq 0 \quad \text{and} \quad C_i - t_i \cdot f_i(\pi_F(t_i); R_i; G) \leq 0.$$

Calling μ and υ the Lagrange multipliers associated with the previous constraints, the first-order conditions for a t; C; G solution of the maximization problem are

$$\forall i \qquad 0 = \alpha_i \frac{\partial V^i}{\partial \pi_F} - \mu \frac{\partial f^i}{\partial \pi_F} - \upsilon^i \left(-f^i - t^i \frac{\partial f^i}{\partial \pi_F} \right), \tag{8.1}$$

$$\forall i \qquad 0 = \alpha_i \frac{\partial V^i}{\partial R} - \mu \frac{\partial f^i}{\partial R} - \upsilon^i \left(1 - t^i \frac{\partial f^i}{\partial R} \right), \tag{8.2}$$

and

$$0 = \sum_{i=1}^{n} \alpha_i \frac{\partial V^i}{\partial G} - \mu \left(\sum_{i=1}^{n} \frac{\partial f^i}{\partial G} - 1 \right) + \sum_{i=1}^{n} \upsilon^i t^i \frac{\partial f^i}{\partial G}. \tag{8.3}$$

Multiplying the second equation by f_i and adding it to the first and then applying Roy's lemma

$$\frac{\dfrac{\partial V_i}{\partial \pi_F}}{\dfrac{\partial V^i}{\partial R}} = -f_i,$$

we obtain

$$\forall i \qquad 0 = (-\mu + \upsilon^i t^i) \cdot \left(\frac{\partial f^i}{\partial \pi_F} + f^i \cdot \frac{\partial f^i}{\partial R} \right),$$

that is,

$$\forall i, \qquad t^i = \frac{\mu}{\upsilon_i} \quad \text{with} \quad \upsilon_i = \alpha_i \frac{\partial V^i}{\partial R} = \alpha_i U_Q^i \quad \text{and}$$

$$\mu = -\sum_{i=1}^{n} \alpha_j \frac{\partial V^j}{\partial G} = -\sum_{i=1}^{n} \alpha_j U_G^j,$$

and then

$$t^i = \frac{-\sum_{j=1}^{n} \alpha^j U_G^j}{\alpha_i U_Q^i} \quad \text{and} \quad \forall (i, j), \ \frac{t^i}{t^j} = \frac{\alpha_i}{\alpha^j} \frac{U_Q^j}{U_Q^i}.$$

This result is identical to the result of Chichilnisky and Heal ([4], p. 446); the taxes are differentiated, and, comparing two countries, their tax ratio is equal to the inverse of the ratio of their marginal utility of numeraire. Thus, a tax is equal to the ratio of social benefit of a marginal abatement to marginal utility of income. Obviously, if one admits that the tax revenue can be redistributed (and not only returned), then, for all $i \in N$, $v_i = v$, and the tax is uniform.

Note that these taxes, which are equal to the marginal cost of abatement in each country, should not be confounded with the marginal social cost of abatement, which is the same for every country (as being equal to the multiplier μ) and is equal at the optimum to marginal social benefit from this abatement. Keeping pollution and taxes constant, the marginal welfare cost of abatement for country i is $\alpha^i(U_F + t_i U_Q - \pi_F(t_i)U_Q)$, and reducing consumption in F leads to lower tax receipts (and thus the received compensation) but to higher available income to consume more numeraire. Each country maximizing its utility, we have $U_F - \pi_F(t_i)U_Q = 0$, so the cost is

$$\alpha^i \frac{dV^i}{df} \Big|_{t;G} = (\alpha^i U^i_Q)t^i = -\sum_j \alpha^j U^j_G.$$

A tax can also be written as the ratio of marginal disability of abatement to marginal utility of income:

$$t^i = \frac{\dfrac{dV^i}{df} \Big|_{t;G}}{\dfrac{\partial V^i}{\partial R}}$$

8.3.2 Accounting for Side Effects — In the following version of the model, we add macroeconomic effects of the taxes: loss of competitiveness on international markets, sectoral adaptation, and double dividend from the recycling of a carbon tax. These net macroeconomic impacts can be interpreted as a reduction or an increase in the income available for consumption: $R_i(t_i) = R_i(0) - S_i(t_i)$, where $S(t)$ are the side effects associated with the tax ($S' > 0$).

The previous first-order condition (8.2) becomes

$$\forall\, i \in [1, n], \qquad 0 = \alpha_i\left(\frac{\partial V^i}{\partial \pi_F} - S'_i \frac{\partial V^i}{\partial R}\right) - \mu\left(\frac{\partial f^i}{\partial \pi_F} - S'_i \frac{\partial f^i}{\partial R}\right) - v^i\left(-f^i - t^i\left(\frac{\partial f^i}{\partial \pi_F} - S'_i \frac{\partial f^i}{\partial R}\right)\right); \qquad (8.4)$$

added with (8.2) and multiplied by $(f_i + S'_i)$, it gives

$$\forall\, i \in [1, n], \qquad t^i = \frac{\mu}{v_i} + \frac{S'_i}{\left(\dfrac{\partial f^i}{\partial \pi_F} + f'_i \dfrac{\partial f^i}{\partial R^i}\right)}$$

and thus $t^i \leq \mu/v_i$ because the denominator of the additional term is negative and S' positive in the general case.

Once again the taxes are differentiated and the marginal social costs of abatement are equal. When taxation generates side effects, the planner should levy a tax all the less high, as these costs are important at the margin (see the numerator of the additional term) and the marginal impact of the tax on consumption of F is limited (see the denominator, equal to the compensated variation of energy consumption). This confirms the nonoptimality of a uniform tax when countries are distinguished by their systems of preferences or macroeconomic reactions to the tax.

8.4 Policy Implications: Some Paradoxes about Negotiability

It follows that, if tax revenues are assumed not to be redistributed internationally, the optimal character of a uniform tax is challenged by many factors of heterogeneity: differences in marginal utility of income and in marginal utility of energy services, uneven access to the best available technologies, and country-specific side effects (additional cost or benefit) of a tax. These factors are apt to pose a problem of procedural efficiency of negotiating a uniform carbon tax if one accounts for the following constraints on policymakers:

First, in terms of aggregated welfare, collective optimum is reached when the marginal welfare cost of abating is equal across countries. As a consequence, countries characterized by a low price elasticity on the demand side or a low technical flexibility on the supply side should be conceded lower taxes (or higher compensations) whereas most of the emission abatement should be operated by countries characterized by high energy price elasticities and high substitution potential between fossil energies and carbon-free energies.

Second, this would not raise any problem if information about price elasticities and technical potentials could be easily revealed. However, parameters determining the balance of gains and losses for each country are far from being tangible. First, energy economists know that long-run income and price elasticities are very controversial issues, especially the respective weight of "autonomous" technical progress and "price-induced" technical progress, and, second, the double dividend of the recycling of a carbon tax, which is macroeconomic in nature, is by definition not observable ex ante.

Third, in a context in which each government must overcome domestic conflicts to adhere to an international agreement, even in the case of a no-regret policy,[14] there might be an asymmetry between the convincing power of intangible parameters surrounded by hard controversies and the symbolic value attached to the tax level. This level is likely to be viewed as an indicator of the required effort and of the risks in terms of international competitiveness; to put it another way, the tax level is tangible, and the economic double dividend will remain both intangible and controversial to the "losers" of such a change in the fiscal system.

Finally, governments will then tend to adopt strategic behavior so as to maximize compensation that they will receive; they will put to the forefront all kinds of arguments demonstrating the low elasticity and low technical adaptability of their country. This would undermine a negotiation process both on a differentiated tax and on compensations accompanying a uniform tax.

Thus, there is no obvious reason that such compensations will be more easily negotiated than differentiated taxes. A system of country-specific taxes or a uniform taxation accompanied by transfers across countries are formally equivalent in terms of quantity and quality of the required information. Deriving absolute conclusions about relative procedural advantages and deadlocks of each system is beyond the scope of economic analysis and would imply considering the sociological, institutional, and cultural determinants of the acceptability of each system.

We can nevertheless make some steps forward. After the Conference of Parties decisions in Berlin (March 95), we are indeed engaged in a sequential process. We must decide today not what will be the optimal solution for the twenty-first century but rather the first step of a precautionary strategy that allows for further adaptations and corrections. This is supported by theoretical research (Manne and Richels [19]; Hourcade and Chapuis [14]) and suggests that the search for strict no-regret policies should prevail over the short run.[15]

If no international transfers are operated, the adoption of no-regret measures

[14] A no-regret policy, which is supposed to remove current market and institutional imperfections to improve environmental quality without decreasing the size of the economy, is not a "free lunch": It implies paying the transaction costs of removing these imperfections, which might be politically sensitive in many circumstances.

[15] This is not in contradiction with the conclusion of the forthcoming report by The Intergovernmental Panel on Climate Change (IPCC) that we have now sufficient scientific understanding of the risks associated with global warming to plea for actions "beyond no-regret." What matters here is (1) that launching no-regret actions now is the maximum that can be expected given the actual degree of concern of international community toward climate change and (2) that implementing these policies now while triggering R&D on low-carbon-emitting technologies does not affect our capacity to mitigate climate change through more drastic and costly GHGs abatements in a second step.

in each country is strictly Pareto improving and are paradoxically restricted to policies that should be adopted regardless of any international coordination. In practice, however, such coordination is necessary for two reasons: (1) Possible distortions might occur in world markets at sectoral levels, and (2) the adoption of a no-regret policy, although yielding net collective benefits, entails transaction costs that a government will more easily cope with under the pressure of an international process.

At this stage the most sensitive distributional issues can be neglected and a learning process triggered along with two dimensions: time progressiveness and geographical progressiveness. Time progressiveness of the taxation is required to minimize adaptation costs and to enable countries to experiment with respect to the outcome of a fiscal reform; geographical progressiveness is the process by which an initial coalition of concerned countries demonstrating the effectiveness of the no-regret policies could be increasingly expanded.[16]

A uniform tax system might be preferred for avoiding distortions in international competition on energy-intensive industries; however, to be actually implemented, such a system will have to fulfill two conditions: very low compensation transfers and low expected net macroeconomic costs. The risk is an agreement on the lowest common denominator. The framework adopted by the European Union at Essen opens an alternative pathway: A differentiated tax system leaves each country to judge what tax level is compatible with a no-regret policy, and the most concerned countries might choose high tax levels, whereas others might choose low ones, lessons from experience being progressively derived by each of them. However, because of the risks of sectoral distortions, such a system is apt to lead to significant tax levels only if differences between these levels are not too high during too long time periods; otherwise, internal pressures will incite governments to lower their initial commitment.

It is only in a second step that the most sensitive issues raised by climate policies cannot be avoided by resorting to the no-regret concept. It is reasonable to expect that most of the no-regret potentials will be exhausted. The only one remaining factors of heterogeneity will be uneven income distributions and differences in utility of energy services stemming from differences in development patterns and lifestyles.

This might be the source of a very sensitive controversy not only between

[16]Numerous analysts think that the emergence of an anticarbon coalition will remain the most likely outcome of the current process. This first coalition, for example, a part of OECD countries, would try to expand step by step to other countries by bilateral negotiations; these would finally result in differentiated implicit prices for carbon; Coppel [5] imagines, for example, a G7 coalition negotiating with Russia, India, and China; these 10 countries are responsible for the three-quarters of the world carbon emissions from energy.

developed and developing countries but also among OECD countries.[17] The underlying critical question is whether heterogeneous preference levels for energy (and other GHG-emitting commodities) stem from objective natural conditions (rigorous climate and low human density) or from manmade infrastructures (geographical distribution of human settlements) or cultural habits (preference for high-powered cars). It is hardly questionable that infrastructure decisions in urban planning, transportation, telecommunications, and energy systems historically lead to contrasted energy consumption levels between countries having rather similar development levels (e.g., between North American and western European countries). An acceptance of differentiated taxes by low-emitting countries for reasons other than natural parameters is then unlikely because this would come to give up correcting structural determinants of energy consumption and to recognize a status of intangibility to habits and behavior of countries making a more profligate use of energy and to give them high-emission rights. Symmetrically, because of the welfare costs entailed during a very long transition period, policies that lead to an increasingly uniform carbon tax will be accepted by high-emitting countries only under the proviso of compensations. The difficulty is that the magnitude of this compensation is likely to be so high that it might not be accepted by other countries and generate centrifugal forces paralyzing the negotiation.[18]

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[17]European expertise accepts, for example, more easily the perspective of reduced (or stabilized) energy consumption than the United States does while starting from a far lower benchmark level.

[18]In an illustrative exercise carried out in 1992, we calculated the global cost for switching from the World Energy Council (WEC) 1986 projections baseline scenario to the normative consumption target proposed by bottom-up modelers for the end of the twentieth century, Dessus and Pharabod [7]. We assumed that the additional efficiency progress (beyond the autonomous progress) would be triggered by energy taxes. In a first simulation we translated the WEC assumptions in a simple formalized expression of the respective role played by prices and autonomous factors in the energy-economy growth decoupling. The results reflected quite well the conventional wisdom prevailing in each region. The United States, Europe, and Japan would keep being very unequal consumers of energy per capita for similar levels of income (no homogenization of consumption patterns); responses to prices would be high in western Europe but weak in the United States; and autonomous technical progress would be high in Japan. In a second simulation we assumed that the view of each country on its own future could be contested and that responses to prices should be higher as the initial per capita energy consumptions are high and to decrease up to an asymptotic value of zero when price increase. The computation of this process toward homogenization of consumption patterns is based on endogenous price elasticities as a function decreasing with the achieved energy efficiency level.

In both cases differentiated taxes lower drastically the total costs of meeting the target at the world level compared to the cost of a uniform tax, but the distributive effects are totally contrasted. However, under assumptions WEC a uniform tax puts the brunt of the total cost on the United States whereas the implementation of differentiated taxes leaves it exempted in 2020 and multiplies its reference energy expenses by a factor of 2.2 only in 2060 to compare with a factor 3.4 for Europe and 3.2 for Japan in 2060. Under the assumption of long-term converging behaviors, the energy expenses are multiplied in 2060 by a factor 2.3 for the United States, but only 1.5 for Europe and 1.2 for Japan when implementing differentiated taxes.

Theoretical analysis suggests only one way out. It is a matter of fact that the main argument against differentiated carbon taxes is the risk of distorting international competition. By chance, making a distinction between energy demand from industry (roughly internationally tradable goods) and energy demand from households and transportation (roughly noninternationally tradable services), the results of the previous sections justify the use of harmonized taxes for industry and resorting to differentiated taxes for final consumers.

If one admits indeed that international markets progressively ensure the harmonization of techniques, then there is a collective interest in avoiding distorting competition (we are close to the first-best world with a total flexibility in trading and technical choices). This is not the case for households and transportation. Then the adoption of differentiated taxation as a function of the level of income and current development patterns is appropriate. However, the progressive convergence of consumption patterns will remain the stumbling block for the process, and the contradictions of interest among nations will be reduced only under the assumption that a high-and-fast technical change induced by price signal[19] is both equitable (the citizen of a rich country will pay more for climate mitigation than the one of a poor country) and efficient in terms of welfare costs.

It is worth mentioning that this conclusion is centered on an issue that is also present in today's discussions around a quota-based approach. Progressive convergence of per capita allocations also implies long-term convergence of energy consumption behaviors. For emissions quota as for differentiated taxes, organizing progressive convergence might be a realistic pathway if, simultaneously, a low-carbon-intensive technical change induced by climate policies grows fast enough to narrow the costs of abating GHG and the contradictions of interests across nations.

Appendix
Revealed Preferences for Energy Services and Development Patterns: A Tentative Model

We assume two countries that have the same utility function $U_i = U_i(Q_i; L_i; H_i)$ and consume a composite good Q_i, leisure activities L_i, and thermal well-being (heating or cooling). To be fulfilled, leisure requires a certain quantity of energy (of transport), $E = \Psi(L, \sigma)$, depending on the shape σ of the city (how

[19]The induced technical change means that the outcome of a steady price signal will move along a given production function and generate a new production function. The importance of this biased technical change on the costs of climate policies was pointed out by Hourcade [13] for France and by Goulder and Schneider [11] for the United States.

diffuse is the city). Heating/cooling requires also a certain quantity of energy depending on the harshness of the local climate conditions φ: $E = \varsigma(H, \varphi)$. Thus, the total energy consumption of country i is

$$E_i = \varphi(L_i, \sigma_i) + \varsigma(H_i, \varphi_i).$$

We assume that $\varsigma_H > 0, \varsigma_\varphi > 0, \varsigma_{H\varphi} > 0, \varphi_L > 0, \varphi_\sigma > 0, \varphi_{L\sigma} >$. Each country maximizes utility under the budget constraint $R_i \geq p_Q Q_i + p_E E_i$ with λ the associated Lagrange multiplier. The first-order conditions are:

$$U_Q = \lambda p_Q,$$

$$U_L = \lambda \varphi_L p_E,$$

and

$$U_H = \lambda \varsigma_H p_E. \tag{A8.1}$$

As the parameters σ and φ appear in the apparent prices of the needs, we can be sure that it will usually result in different levels of consumption across countries.

The planner aims to choose a tax set (t_i) on fossil fuel consumptions (E_i), limiting the emissions to a chosen level. He must obtain a minimal agreement from the involved countries and so does not allow to proceed in lump-sum transfer between countries, but having collected the taxes, he returns to each the revenue of its own tax.

Considering its endowment, the prices and the tax, and the compensation announced by the planner, each country maximizes its utility choosing its demands for Q and E.

Its new disposable income is now $R_i = D_i + C_i$, where D_i is the initial endowment and C the received compensation for tax, and the new price for E: $\pi_E = p_E + t_i$.

The planner has to keep in with two constraints. First, the actual emissions level, which results from the individual countries optimisation, should equal the global level chosen by the planner (we suppose hereafter that the emissions are proportional to the energy consumption). Second, the compensation granted to a country should equal the tax receipts in this country. Letting E^* be the energy/emissions goal, the maximization program of the planner is

$$\max_{t;C} \sum \alpha_i V_i(p + t_i; R_i) \quad \text{with constraints}$$

$$\sum E_i(l_i; h_i) - E^* \leq 0 \quad \text{and} \quad \forall i \; C_i - t_i E_i(l_i; h_i) \leq 0.$$

Calling μ and ν the Lagrange multipliers associated with the previous constraints, the first-order conditions for a (t; C) solution of the maximization problem are

$$\forall i \qquad 0 = \alpha_i \frac{\partial V^i}{\partial \pi_F} - \mu \frac{\partial E^i}{\partial \pi_F} - v^i\left(-E - t^i \frac{\partial E^i}{\partial \pi_F}\right)$$

$$0 = \alpha_i \frac{\partial V^i}{\partial R} - \mu \frac{\partial E^i}{\partial R} - v^i\left(1 - t^i \frac{\partial E^i}{\partial R}\right). \qquad \text{(A8.2)}$$

the envelope theorem gives us that $(\partial V_i/\partial \pi_F)/(\partial V_i/\partial R) = -E_i$, and we obtain $t^i = \mu/\nu_i$ with $\nu_i = \alpha_i(\partial V_i/\partial R) = \alpha_i p_Q U^i_Q$.

This allows us to conclude for differentiated taxes, provided that the marginal utility of revenue is not the same for countries with different conditions (σ,ϕ), that, for example, $\partial^2 V/\partial\sigma\partial R = -(\pi_E/\pi_Q)\,\Phi_{\sigma L} l_R < 0$.

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