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ECONOMIC CONSEQUENCES OF PERMITS ALLOCATION RULES

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ABSTRACT. This paper investigates the economic consequences of permits allocation rules. Following the rapid development of the Kyoto Protocol and the EU Emissions Trading Scheme, it appears critical to better understand the procedure of allocation of permits between countries/firms and its distributive consequences. Indeed, due to intense political lobbying, the free distribution of permits to existing users as a function of a given benchmark ("grandfathering") appears as the best solution to facilitate the agreement to the scheme. This paper discusses the pros and the cons of various other allocation rules, such as *per capita* emissions, *per capita* GDP, relative historical responsibility, or size of population. The main lesson of this study is that the most efficient free allocation methodology (maximizing world's production for a given emissions level) consists in distributing permits based on the quantities of efficient labor, while a more equitable solution consists in distributing permits to each production factor proportionally to its share in production.

JEL Classification: Q40; Q48; Q54.
Keywords: Tradable Permits Market; Allocation Rules; Capital allocation; Factor Income.

RÉSUMÉ. Cet article analyse les conséquences économiques des règles d'allocation des permis à polluer. En raison d'un lobbying politique intense, l'attribution gratuite des permis aux utilisateurs actuels, relativement à un *benchmark* donné (« grandfathering ») est la meilleure solution pour aboutir à un accord. Cet article pèse le pour et le contre d'autres règles d'allocation, telles que le calcul des émissions par tête, ou selon le PIB par tête, la responsabilité historique ou encore la taille de la population. La principale conclusion est que la méthode d'allocation gratuite la plus efficace consiste à distribuer des permis selon les quantités de travail efficace, mais qu'une solution plus équitable est de distribuer des permis à chaque facteur de production selon sa part dans la production.

Classification *JEL* : Q40 ; Q48 ; Q54.
Mots-clefs : Marché des permis négociables ; règles d'allocation ; affectation du capital ; revenu des facteurs.

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1. Introduction

The Kyoto Protocol, which emerged in 1997, states that signatory countries (OECD, Eastern European countries in transition, Russia, Ukraine) should on average reduce GHG emissions by 5.2 percent with respect to 1990 levels during 2008-2012. Individual reduction objectives have been fixed for each country: EU countries agreed on a reduction of –8 percent, the U.S. to –7 percent, Japan and Canada to –6 percent, Russia to 0 percent, and Australia to +8 percent (see TABLE 1). The negotiated solution thus consists in a quantitative restriction of the possibilities to trade exchangeable quotas distributed to individual countries. 174 countries have ratified the Protocol, with the notorious exception of the United States. The first commitment period of the Kyoto Protocol goes from January 1, 2008 to December 31, 2012. Annex 1 covers developed and transition countries which decided on quantified reduction targets during the signature of the Rio Convention, while Annex B covers countries that have agreed precise emissions reductions objectives in the framework of the Kyoto Protocol. The European Union Emissions Trading Scheme (EU ETS) has been created on January 1, 2005 to contribute to reduce by 8 percent CO_2 emissions in the European Union by 2012, relative to 1990 emissions levels. This aggregated emissions reduction target in the EU has been achieved following differentiated agreements, sharing efforts between Member States based (with an internal repartition allowing, for instance, 0 percent to France, –21 percent to Germany or +15 percent to Spain, see TABLE 1). The EU ETS covers energy intensive companies above the threshold of 20MW[2], in application of the Directive 2003/87/EC. It draws on the U.S. sulfur dioxide (SO_2) trading system for much of its inspiration (Ellerman *et al.*, 2000), but relies much more heavily on decentralized decision making for the allocation of emissions allowances, and for the monitoring and management of sources (Kruger *et al.*, 2007). Each country is required to develop a National Allocation Plan (NAP), which, among other design features, addresses the national CO_2 emissions target. The sum of NAPs determines the number of quotas distributed to installations in the EU ETS. In this institutional framework, 2.2 billion allowances per year have been free distributed during 2005-2007. 2.08 billion allowances per year will be distributed during 2008-2012. The allocation methodology consisted in a free distribution of quotas in proportion of recent emissions. Some Member States also allowed for auctioning in Phase I (2005-2007) and II (2008-2012), but the maximum shares of 5 and 10 percent allowed by the Directive were not reached. These provisions refer to the first two trading periods only: The future of the EU ETS will look quite different with the introduction of auctioning during Phase III (2013-2020), which will cause major challenges in the future development of the scheme. In fact, due to free allocation, several hurdles prevent the good functioning of a tradable permits market.

2. Sectors covered include power generation, mineral oil refineries, coke ovens, iron and steel and factories producing cement, glass, lime, brick, ceramics, pulp and paper, which represents 10,600 installations.

Table 1 - Status of the Kyoto Protocol and differentiated agreements of CO_2 emissions reduction in the EU

Members of Annex I	CO_2 emissions in 1990 (gigagrams)	Part in percent of emissions in 1990 among Annex I members	Kyoto target 2008-2012	Part in percent of EU emissions in 1990	Differentiated agreements of CO_2 emissions reduction in the EU
			percent relative to 1990 emissions levels		percent relative to 1990 emissions levels
United States	4,957,022	36.00	93		
European Union	3,288,667	24.05	92		
Austria	59,200	0.43	92	1.7	87
Belgium	114,410	0.84	92	3.2	92.5
Denmark	52,025	0.38	92	1.7	79
Finland	53,900	0.39	92	1.7	100
France	366,536	2.68	92	14.7	100
Germany	1,014,155	7.42	92	27.7	79
Greece	82,100	0.60	92	2.4	125
Ireland	30,719	0.22	92	1.3	113
Italia	428,941	3.14	92	12.5	93.5
Luxembourg	11,343	0.08	92	0.3	72
The Netherlands	167,600	1.23	92	4.8	94
Portugal	42,148	0.31	92	1.6	127
Spain	227,322	1.66	92	7.0	115
Sweden	61,256	0.45	92	1.6	104
UK	577,012	4.22	92	17.9	87.5
Australia	288,965	2.11	108		
Canada	462,643	3.38	94		
Iceland	2,172	0.02	110		
Japan	1,155,000	8.45	94		
New Zealand	25,476	0.19	100		
Norway	35,514	0.26	101		
Switzerland	45,070	0.33	92		
Liechtenstein	208	n.a.	92		
Monaco	n.a.	n.a.	92		
Transition Economies	3,364,259	24.60	103		
Bulgaria	82,990	0.61	107		
Czech Republic	165,792	1.21	92		
Estonia	37,797	0.28	92		
Hungary	71,673	0.52	110		
Latvia	22,976	0.17	92		
Lituania	n.a.	n.a.	92		
Poland	414,930	3.03	108		
Romania	171,103	1.25	107		
Russian Federation	2,388,720	17.47	100		
Ukraine	n.a.	n.a.	100		
Slovakia	58,278	0.43	92		
Croatia	n.a.	n.a.	95		
Slovenia	n.a.	n.a.	92		
Total 1990	13,675,067	100	95		

Source: Barrett (1998), Marklund and Samakovlis (2007).

In this article, we study the free allocation rules of tradable permits and their consequences on labor and capital income, as well as on capital allocation, between countries/firms. If the approach decided in Kyoto ("grandfathering" which consists in allocating free permits based on a benchmark of past emissions) is understandable to achieve the political acceptability of the Protocol between developed countries, it may not be accepted by countries like India or China with over one billion inhabitants and whose total emissions will increase with their economic growth. These countries advocate a *per capita*[3] allocation of permits. Equity in allocation rules lies at the heart of the debate, and it has been widely discussed in the literature (see Godard, 1997 and 1999). Other than the choice of the allocation rule itself, it appears more generally problematic to distribute permits following the appropriate criteria, be it emissions (total or *per capita*[4]), GDP (total or *per capita*), population, size or the historical relative responsibility in the growth of GHG emissions as measured by past emissions (see Müller, 1998, for a list of different possibilities in pollution permits allocation). Thus, we need to weigh the economic consequences of these choices.

Intuitively, a population allocation rule will benefit to developing countries in every aspects: production, movement of capital and income from the permits market. In contrast, a grandfathering rule will benefit to developed countries. A *per capita* allocation rule will have different size effects, depending on the ratio of population in Northern and Southern countries. With the same level of population, *per capita* rules will lead to the same consequences as a level allocation rule (emissions, capital, production), and thus perform similarly. With different levels of population, developing countries will benefit only if they have lower levels of population.

Thus, our analysis allows us to be more specific on the economic consequences, inside and outside countries/firms, of these different allocation rules. We first analyze the effect of free permits allocation on production factors income. We show that an allocation proportional to the share of production factors in production avoids the income distortion between capital and labor. Second, we analyze the effects of allocation rules on capital allocation between firms. We show that an allocation proportional to efficient labor between firms leads to a proportional reduction on production, but does not imply distortions in capital allocation.

In the remainder of the article, we develop the economic intuition of theses results.[5] The article is organized as follows. Section 2 describes various permits allocation rules. Section 3 details the effects induced by permits allocation. Section 4 concludes.

2. Permits allocation rules

Pollution permits constitute by definition a framework for environmental regulation that defines a quota of emissions (the number of permits), and leaves it to the market to ensure its repartition.

3. *i.e.* proportional to the size of the population.

4. The *per capita* approach has been first proposed by Agarwal and Narain (1991). Besides, it has been examined in depth by philosophers (Jamieson, 2001; Singer, 2002; Gardiner, 2004, among others). Hence this approach is not uniquely determined by us, and it seems perfectly legitimate to study its economic consequences.

5. The readers interested by a formal approach could refer to Jouvet, Michel and Rotillon (2002, 2005, 2010).

However, relying on the market does not solve everything: capital transfers, production and the distribution of incomes depend on the permits' allocation methodology. Their distribution forms an endowment that affects the equilibrium. Next, we examine allocation rules based on grandfathering and auctioning.

2.1. Grandfathering allocation *vs.* auctioning

Theoretically, every system or any allocation is possible, but in practice grandfathering has been the basis of domestic tradable permit schemes in the United States, and is generally considered as unavoidable (Tietenberg, 2002). In 1975, the U.S. Environmental Protection Agency (EPA) used permits trading in order to fight air pollution. In 1995, the U.S. Acid Rain Program was established (under Title IV of the Clean Air Act Amendments of 1990) to drastically reduce SO_2 emissions by electric utilities. This ambitious program sets a permanent cap to SO_2 emissions by utilities at about half of their annual emissions in 1980. In Denmark, a tradable permits market for regulating CO2 emissions in the electricity sector is voted by the Parliament in 1999. In these experiences, permits are grandfathered, with the exception of the SO_2 in the U.S. where 2.8 percent of permits are auctioned each year.

The main reason behind such practice is that with this system firms only pay for additional permits, while they would pay for all of them in the case of auctioning. As a consequence, they consider grandfathering more acceptable than any other allocation rule, even if it brings only a small revenue to the State, thereby excluding the possibility to benefit from the so called "double dividend" (see Oates, 1995 and Goulder, 1995). A study by the Congressional Budget Office (2000) suggests that with the rule of grandfathering in a tradable permits market for CO_2 emissions, low-income households could lose several hundred dollars *per* year, while on the contrary high-income households could have a net gain of 1,500$ *per* year. As shown by Parry (2002), "*grandfathered permits create windfall gains for shareholders, who are concentrated in high-income groups, because such policies hand out a valuable asset to firms for free. There is no windfall gain to wealthy households under auctioned* permits *or emissions taxes; instead, the government obtains revenues that can be recycled in tax reductions that benefit everyone or disproportionately favor the poor*".

In a given economy with tradable permits markets, we can define the behavior of the firm with a given stock of capital and permits. We assume that this behavior is competitive and is function of the real wage rate and the real permits price. The firm chooses its technology and the level of employment that maximizes its income, net of wage costs and expenses on the permits market. This net income (the gross operative surplus as defined by Hahn and Solow, 1995) is distributed to shareholders, who own the stock of capital. The equilibrium is generally defined by equalizing supply and demand on both the labor and permits markets. On the capital market, the equilibrium is not characterized by the standard usage cost, but by capital owners' arbitrage condition. This condition interacts with firms' permits allocation, and imposes to equalize average capital productivities instead of marginal productivities. In presence of free tradable permits allocation, these two productivities –marginal and average– are generally not equal. Indeed, following Hahn and Solow (1995), "(...) *we*

take it to be characteristic of capitalist firms that their profits go to the suppliers of capital. We assume, therefore, that savings (…) are used to buy shares in the gross operating surplus of firms".

Profits *per* unit of capital represent the return on investment that is given to the shareholder, *i.e.* the owner of the capital stock. In this approach, the owners of the capital stock are the capitalist part of households. Considering an overlapping generations model framework, the owners of capital are the old agents (Jouvet, Michel and Vidal, 2002a). According to production optimization decisions, the capital return is determined not only by the capital marginal productivity, but also by the market value of the free endowment of pollution permits given to the firm, valued at the market price. The latter represents what is called *windfall profits* in the literature.

It can also be noticed that, if all the permits were auctioned instead of being given for free, then the regulation with tradable emissions permits would be strictly equivalent to a regulation with an emissions fee. On the other hand, a simple command-and-control regulation would not generate such windfall profits. Thus, the debate does not seem to be about quantity *vs.* price regulation, but about the assignment of property rights on the pollution. With free permits, the rent is given to the firms, which distorts the capital market. This adverse effect would not appear with price or command-and-control regulations. Hence, we detail other allocation rules below.

2.2. Some alternatives to grandfathering allocation

The effect of free permits allocation appears particularly relevant in a North-South context, where developing countries anticipated greater costs than benefits from adopting emissions reductions policies based on grandfathering, and thus refused to take part to the Kyoto Protocol. Nevertheless, numerous studies that attempt to evaluate these costs do not take into account developing countries. This is the case for instance in Bohm and Larsen (1994), who only include European and former Soviet Union countries. They show that permits allocation rules based on population or GDP will not induce participation from most Eastern European countries, given the high costs associated with such policies. They further identify a set of initial permits allocations that would at least compensate these countries. Besides the reduced geographic scope, their analysis only takes into account the repartition of emissions reduction costs and neglects the general equilibrium effects of the different allocation rules under consideration. On an even narrower perspective, Koutstaal (1997) considers the economic consequences of different allocation rules only at the level of the EU 12. It seems nevertheless obvious that such a research question may only be examined in a general equilibrium framework, and may not be limited to distributing equally the burden of reducing emissions. More particularly, this question shall take into account the likely effects on capital reallocation, induced by global interest rates changes following the distribution of permits (Jouvet, Michel and Vidal, 2002b).

The central issue lies in finding the appropriate parameter to implement the initial allocation of permits. Opinions vary greatly in this respect but we can reduce them to level allocation rules (based on emissions, production, capital stock, efficient labor[6]) or *per capita* allocation rules (Jouvet, Michel and Rotillon, 2002 and 2010). These allocation rules are defined with respect to equilibrium variables in a world without permits, *i.e.*, without restriction on emissions. In such a world, in equilibrium, production levels, emissions and capital stocks are proportional to efficient labor H and the world production is maximal.

Applying the same proportionality rule to efficient labor in a world with allocations permits (*i.e.* equalizing the ratios of permits E_2/E_1 in the two countries with the ratios of efficient labors H_2/H_1)–affects the equilibrium by reducing proportionally world's production due to the environmental constraint. The economic intuition unfolds as follows. If one distributes permits proportionally to production factors, between Northern and Southern countries, there are no effects on efficiency. If one does not respect the proportionality rule, some discrepancies between countries have been introduced. Indeed, if allocation rules do not respect the proportionality principle anymore, trading will appear on the markets in terms of capital movements and permits trading. This appears because if the two ratios of efficient labors and of permits allocations are different, there is an inefficiency of capital allocation which results from the effects of permits allocation on the return of capital. This is due to the fact that the average return in this case is not equal to the marginal one, and depends on the value of permits given for free in each country. Then, capital must be reallocated to restore the equality of capital returns between the two countries. Therefore, world production can be increased by reallocating capital and keeping the same level of world's total emissions.

If countries have the same technology, an allocation of permits proportional to efficient labors induces also proportionality to emissions or productions. In this case, grandfathering rules reduce proportionally productions and emissions without any change in capital allocation.

To study the effects of a rule proportional to population N, we suppose as in Copeland and Taylor (1994) that the human capital *per capita*, $h_2 = H_2/N_2$, is lower in Southern countries compared to Northern countries, $h_1 = H_1/N_1$. With such a rule, the ratio of permits E_2/E_1 is equal to the ratio of population N_2/N_1, but it is higher than the ratio of efficient labor H_2/H_1. Hence, the Southern country is a net winner in equilibrium in terms of free permits (assumption of *windfall profits*). With the same amount of total emissions (and thus permits) as in the former case, the South sells permits, receives more capital and produces more. It also emits more, but world's production has been reduced. This emphasizes again the standard dilemma equity *vs.* efficiency. We also note that the redistributive effect is only partial: in equilibrium, income *per capita* is lower in the South compared to the North.

One last type of rule consists in applying proportionality to *per capita* variables (human capital, production levels, or emissions). Such a rule is in favor of the smallest country in terms of population, be it North or South. It appears clearly that such a rule, which would

6. Note we define classically the productivity of one unit of work (with reference to human capital stocks) H as being efficient labor (see Copeland and Taylor, 1994, for the distinction North/South).

give the same number of permits to two countries having the same *per capita* variables but that are very different in terms of size, is not credible.

Having reviewed various kinds of allocation rules, we examine more closely their induced effects in the next section.

3. Effects induced by permits allocation

This section examines the effects of permits distribution on the allocation of capital. We are first interested in the effect of permits allocation inside firms in terms of factor income. Second, we study the impact of allocation between countries in terms of world production and global capital allocation. We aim at identifying specific effects on marginal productivity and on the entire production function. Inside the firm, we also aim at identifying specific effects on the remuneration of production factors.

Let us examine the argument that the introduction of tradable permits markets may yield to international capital re-allocation. If permits are distributed for free to firms, it modifies the value of the firm and creates distortions in equilibrium where marginal and average productivities are not equal anymore. Hence, the free distribution of permits modifies arbitrage rules in the economy. In a two countries setting, if allocation rules are not applied similarly between the two countries, it will modify the returns to capital and hence yield to capital re-allocation. By looking further than emissions reduction costs, the choice of one rule *vs.* another has redistributive consequences on the wealth produced, which explains the behavior of some countries during international climate negotiations.

3.1. Effects induced on factors' income inside firms

Introducing environmental regulation with pollution permits allows firms to consider permits, and more generally the environment, as a new production factor. Indeed, by considering how the environment interacts with the classical production factors (labor and capital) inside its process, the firm should improve its global productivity (see Bréchet and Jouvet, 2009). By taking into account pollution permits within the whole optimization process, this corresponds to enlarging the set of production of the firm, and leads to productivity improvements (see Anderson and Newell, 2004, for empirical evidence of this effect).

Thus, when comparing situations with/without environmental regulation, we can observe a change in the marginal productivity of production factors. Intuitively, for the same level of production with/without environmental regulation, we have two or three production factors. Therefore, the share in production of each factor cannot be the same in the two cases, as well as their marginal productivity.

Thus, we can emphasize the impact of permits allocation on the earning of production factors: the underlying production function has three factors (capital, labor and emissions) and the effect on the marginal productivities comes from the emissions cap. This leads us to

consider the effects of free allocation *vs.* other rules on the earning of production factors and wealth distribution (Jouvet, Michel and Rotillon, 2010), which is another debate highlighted by the introduction of tradable permits markets.[7]

Besides changes in factors' earnings, let us examine the likelihood of increasing profits as a consequence of initial allocation. Permits have indeed a positive value. In a production function with three factors (including pollution permits), marginal productivity must therefore be used towards one additional factor. The marginal productivities of the two other factors (capital and labor) are reduced in a similar way. However, the free allocation of permits introduces another source of asymmetry since they represent windfall profits for capital owners. In this setting, giving permits for free to the firm (and thus to shareholders) allows to compensate the decrease of marginal productivity of capital in terms of return. With a positive permits price, the capital return is defined by the marginal productivity of capital plus the value of permits. Therefore, without allocation of permits to workers, labor income decreases more than capital income. Hence, a suggestion could be to distribute free permits to workers as advocated by Jouvet, Michel and Rotillon (2010). Indeed, if the practice consists in distributing permits to firms and/or countries, nothing prevents from distributing them to other agents too. That is why, during the preparation of the Kyoto Protocol, some critics have argued that the distribution of permits shall be extended not only to countries (the Parties), but also to private domestic entities.

As detailed above, the fact that permits have a positive value modifies firms' wealth, and influences factors' earning by defining the value of one unit of production, net of firms' permits purchasing costs. More precisely, capital's earnings can be equal, superior or inferior to their marginal productivity depending on the level of compensation induced by the free permits allocation to firms. This effect may be seen as an externality of the introduction of the permits market. A solution consists in allocating permits free of charge to production factors proportionally to their contribution to production. In fact, grandfathered permits do not necessarily create windfall gains for shareholders if their allocation is judiciously made to all production factors.

3.2. Permits allocation between countries: effects on world's production and profits

The effect on firms' wealth lies at the heart of the debate, as the factor reducing marginal productivities is directly linked to the fact that permits have a positive value. A positive value for permits induces a reduction in world's production, even in the case where production capacities are fully used in each country. This reduction will pass on marginal productivities of production factors, such as labor and capital, and on capital reallocation. The main difference between the earnings of capital and labor is that extra effects occur following the free distribution of permits to firms in the case of capital.

7. Note that all the results derived in this section concerning allocation rules are also valid in the context of a dynamic analysis, as shown by Jouvet, Michel and Rotillon (2005).

As detailed above, an international proportional allocation rule does not imply capital reallocation, and only the factor income effect inside firms will be observed. If we consider a non proportional allocation rule, then we observe two effects: *1)* the reduction of world's production due to the capital reallocation among countries, and *2)* the reduction factor on marginal productivities of capital and labor. Note that as allocation goes further away from a proportional rule, the reduction in world's production becomes increasingly important. If all permits are given to poor countries, which are characterized as being less productive, a huge reduction in world's production will occur because of capital reallocation in favor of the less productive firms. This sheds light on the recurrent discussion between countries about the initial distribution of permits in a tradable market. Regarding efficiency, the level allocation rules seems to be the best. But it does not allow for any evolution of the relative income between countries.

It appears even possible that the earning of capital increases due to an increase in profits, linked to the positive value of permits freely distributed to firms. If we consider the case of an effective but weak environmental constraint, with an important share of permits distributed freely to firms, then the value of permits given to firms will more than compensate production losses linked to environmental regulation. Overall, firms' profit increases with respect to a situation without permits, and as a consequence the earning of capital, is higher than without environmental regulation. More importantly, the factor reducing marginal productivities modifies the classical equivalence between environmental policies based on permits *vs.* taxes as regulatory instruments. This equivalence indeed supposes that no permit is freely distributed to firms. If firms benefit from a free permits allocation, then it is not equivalent anymore to use a tax or permits in environmental regulation policies, due to the changes in profits induced by this free allocation.

There exists a possibility to distribute permits freely while equating production factors' marginal productivities and their earning. This allocation should compensate marginal productivity losses by a gain in permits. As detailed for the earning of capital (where the marginal productivity loss may be compensated by the value of permits distributed to firms), we need to introduce the same system for other inputs like labor. The permits allocation equating marginal productivities and factors' earnings corresponds to a distribution proportional to the contribution of each production factor. Based on the usual standards of 1/3 for capital and 2/3 for labor, only 1/3 of permits shall be distributed freely to firms as the share of capital in production, while 2/3 shall be distributed directly and freely to workers as the share of labor in production. Note that permits distribution avoids dealing with the double dividend issue, and the creation of an institutional body managing the transfers linked to permits sales.

4. Conclusion

This paper is devoted to studying the economic consequences of different permit allocation rules, including *per capita* emissions, *per capita* GDP, relative historical responsibility, and size of population. Four different types of conclusions hold.

First, a level allocation rule (proportional to output, emissions or physical capital) reduces production and emissions in different countries proportionally to the permits allocation. In this case, each country uses exactly its allocation of permits, and the equilibrium allocation of capital is the same as in the economy without permits. In fact, such an allocation rule is efficient, *i.e.* it allows maximum production for a given total world allocation of permits. The level allocation rules proportionally reduce output in different countries whatever their relative wealth.

Second, a North-South distinction (Copeland and Taylor, 1994) assumes higher level of efficient labor *per capita* in the North. This implies that a population allocation rule leads to a North-South ratio of permits smaller than the level allocation. This allocation is beneficial for the developing country, increasing capital and production. Moreover, the South is net seller of permits, which provides an additional income. However, the *per capita* income remains lower in the Southern country compared to the Northern country, and world's production is reduced more than in the case of a level allocation rule. This is due to capital reallocation.

Third, *per capita* allocation rules (proportional to *per capita* output, emissions or physical capital) induce a size effect. If the population in the developing country is lower than the population in the developed country, these rules have the same effects as the population rule. But if it is larger, the developing country benefits from the *per capita* allocation rules.

Fourth, when free permits are distributed to firms, the equilibrium does not satisfy the equality of factor income with marginal productivity. There exists a distribution of permits which restores this equilibrium property, and avoids the problem of the use of the auction's revenue by the government (the so-called double dividend problem). It consists in allocating freely all permits to production factors proportionally to their contribution to production.

These results shed some light on the ongoing discussions between countries about the initial allocation of permits in a tradable permits market and its redistributive effects. Regarding efficiency, the level allocation rule seems to be more satisfactory. However, it does not account for any evolution of the relative income between countries. Therefore, the debate over allocation rules in tradable permits markets should be linked to redistribution policies.

J. C., P.-A. J., P. M. & G. R.

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