Internal Carbon Pricing in the Multidivisional Firm*

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Abstract

In response to environmental concerns, multidivisional firms running internal markets often seek to have the associated internal (or transfer) prices incorporate their social cost of pollution. We develop a theoretical rationale and framework for this phenomenon. Modeling two vertically related subsidiaries located in different jurisdictions, we examine how transfer prices would convey mandatory carbon fares, and consider the impact on each subsidiary's production and emissions abatement. Thereby, we also show how the firm's environmental strategy might interact with fiscal compliance. Through transfer pricing, finally, a carbon fare in one jurisdiction can have an incidence on the other jurisdiction's subsidiary; implications for environmental governance are discussed.

Keywords: Greening global value chains; Transfer pricing; Fiscal and environmental compliance; Environmental governance

JEL Codes: D21, M21, Q53

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Most production in modern economies occurs within organizations, and this production is regulated only to a limited extent by [market] prices. (Stiglitz, 1991, p.15)

[Market] Carbon pricing by itself may not be sufficient to induce change at the pace and on the scale required for the Paris target to be met, and may need to be complemented by other well-designed policies tackling various market and government failures, as well as other imperfections. (Stern and Stiglitz, 2017, p.3)

1 Introduction

Economists attribute the depletion of environmental resources primarily to market failures. Scholars and policymakers have accordingly developed market-based instruments to overcome these failures. To deal with CO_2 emissions and climate change, for instance, a widely advocated policy instrument is the implementation of a carbon fare (Nordhaus, 2019; Timilsina, 2022). The Stern-Stiglitz report asserts that setting a fare on carbon between 50 and 100 US$ per ton of CO_2 (tCO_2) by 2030 might indeed support the Paris Agreement target of stabilizing average temperature increase below 2% (Stern & Stiglitz, 2017).

As Stiglitz (1991) and Stern and Stiglitz (2017) pointed out, though, environmental resources are allocated not only through markets, but also within organizations, and the latter are also subject to malfunction. Numerous stylized facts and case studies tend indeed to corroborate organizational failures. Wright and Nyberg (2017)'s five cases, for instance, show companies struggling to integrate climate change considerations into business-as-usual practices. DeCanio (1993, 1998), Reinhardt (2000), Johnstone (2007), and the empirical literature on the Porter Hypothesis (covered notably by Ambec and Lanoie, 2008) provide further evidence of firms' inefficiencies in dealing with environmental matters.

Since the 1990s, researchers have thus been also looking at some organizational remedies which, together with the appropriate market ones, could help overcome environmental externalities (surveys of earlier contributions include Gabel and Sinclair-Desgagné, 2000; Johnstone, 2007). One such organizational remedy, pointed out early on by Gabel and Sinclair-Desgagné (1994), are the internal - so-called 'transfer' - prices which apply to transactions between subsidiaries in multidivisional firms. Over the last decade, in response to more stringent public policies and growing social demands, several multinational enterprises went on to rely on this instrument, adjusting transfer prices so their respective internal markets incorporate the social cost of greenhouse gases emissions (Aldy & Gianfrate, 2019).[1] In 2012, for example, Microsoft introduced a carbon fee on transactions between its departments, which holds across more than 100 countries. Thanks to imposing a 5 US$ charge per tCO_2 on its business groups' operating expenses (targeting travel emissions, the energy consumption of datacenters, etc), the company succeeded in three years to reduce its CO_2 emissions by 7.5 million metric tons (DiCaprio, 2015). In a similar move, Ben & Jerry's has applied a carbon fee across its value chain to incentivize emissions-reducing projects. Its dairy suppliers were then led to develop new technologies for the management of manure, which initially accounted for 42% of their overall carbon footprint (Chang, 2017). All in all, the Carbon Disclosure Project (2016) reports that, as of 2017, more than 1,200 companies had adopted an internal carbon pricing (ICP) strategy, or were planning to do so. These firms believe that using such a tool will help assess the risks and opportunities of their GHGs emissions, drive R&D investments towards eco-innovation (Stern & Stiglitz, 2017), and foster the production and delivery of environmentally friendlier intermediate goods (Sinclair-Desgagné, 2013). This paper's raison d'être is to reconsider this rapidly spreading practice from an applied-theory perspective. Our intent is to enhance the understanding of what multidivisional firms might do to cope with current regulatory and social pressures, and what this implies for climate management, the diffusion of local environmental regulations, and the relationship between environmental and other (namely fiscal) policies.

There is a small but fast-growing literature on internal carbon pricing. Contributions include descriptions and assessments of current practices (For a recent account from an empirical perspective, see Gorbach et al., 2022; Hansen, 2023), analyses of the internal and external drivers/incentives for firms to implement ICP (Bento & Gianfrate, 2020; Chang, 2017; Trinks et al., 2022), and appraisals of ICP's impact on the firm's environ-

[1] Gabel and Sinclair-Desgagné (1994) mention earlier experiments in the chemical, steel and automobile industries. But the practice was relatively scarce at the time.

mental performance (Zhu et al., 2022) or financial results (Ma & Kuo, 2021). We add to these respective streams a theoretical framework for developing and assessing ICP which acknowledges the firm's internal structure and transactions.[2]

Our analysis builds on, and extends, several research areas.

Related literature. First, the study of transfer pricing practices, particularly as they have to do with the firm's fiscal strategy, constitutes an important stream of the Managerial Accounting and the Accounting & Economics literatures.[3] In a seminal article, Hirshleifer (1956) considered a decentralized organization (i.e. one in which transfer prices are set by the firm's divisions); when there are no taxes on the firm, the optimal transfer price charged by an upstream subsidiary would then be chosen as if decision-making were centralized (i.e. made at the headquarter); it would correspond to the supplying division's marginal cost of production. Several works were next conducted under various scenarios involving a vertically integrated monopoly, subsidiaries operating under different tax regimes, and transfer pricing decisions being centralized (Copithorne, 1971; Horst, 1971) or decentralized (Baldenius et al., 2004; Bond, 1980). The upstream subsidiary's marginal cost of production was still focal in setting optimal transfer prices, but fiscal arbitrage might also weigh in. The central role usually ascribed to transfer prices is to reduce the firm's overall taxes on profits (see, for instance, Clausing, 2003; Cristea and Nguyen, 2016; Davies et al., 2018).[4] The strategic role of transfer pricing was then raised by, among others, Narayanan and Smith (2000) and Göx (2000). Considering a duopoly, the former showed that a firm's competitive advantage might result from adopting a decentralized organization. Considering a duopoly as well, while assuming that the competing firms are centralized, the latter showed that the equilibrium transfer prices might differ from the upstream subsidiaries' respective marginal cost of production

[2] Ma and Kuo (2021) propose an alternative theoretical account of ICP, with the firm modelled as a production function.

[3] See, e.g., Göx and Schiller (2006), Beer et al. (2020), and Kumar et al. (2021) for surveys.

[4] While the Accounting literature has explored the role of transfer pricing in corporate tax avoidance, the Standard Tax Competition and New Economic Geography literatures have studied jurisdictions' competitive reaction to firms' location decisions. The reader is referred to Keen and Konrad (2013) for a survey on tax competition and coordination.

when transfer pricing decisions are observable. Some additional roles that transfer pricing might play in organizational design, relational contracting, managing collusion between subsidiaries, and product differentiation were respectively examined by Holmstrom and Tirole (1991), Baker et al. (2002), Shor and Chen (2009), and Matsui (2011). Supplementing these contributions, this paper will now study transfer pricing as an instrument of the multidivisional firm's environmental strategy.

Another related area is the one on environmental taxation across vertically connected markets. The early literature contemplating imperfectly competitive markets had shown that the optimal pollution tax (i.e. the one maximizing social welfare) would lie below marginal environmental damage, as it trades off moderating the polluting firms' exercise of market power with making them internalize their negative environmental externalities (Barnett et al., 1980; Buchanan et al., 1969; Oates & Strassmann, 1984). Later scholars were to strengthen this result while adding considerations pertaining, for instance, to the relocation of activities (Petrakis & Xepapadeas, 2003) or factor markets (Parry et al., 1999). More recently, in works closer to ours, Hamilton and Requate (2004) and Sugeta and Matsumoto (2007) went on to study environmental regulation when it takes into account its impact on vertical production structures. In the presence of strategic international trade policy and intranational contractual relationships, Hamilton and Requate (2004) established that the optimal measure towards a polluting input under both quantity and price competition is the Pigouvian tax. Sugeta and Matsumoto (2007), on the other hand, compared the efficiency of an input tax on a monopolistic upstream division versus that of an emissions tax on a duopolistic downstream division; they found that the upstream division will price-discriminate less (more) as the input (emissions) tax increases. While these two contributions considered vertical structures respectively ruled by contractual or market relationships, we assume this time around that the vertical structure is governed by transfer pricing. And while they respectively took on key contextual elements such as strategic trade or market concentration, we focus on fiscal policies. This paper centers on the multidivisional firm, however; it is beyond its scope to provide a complete analysis of the emissions fare each jurisdiction will set at the equilibrium of a game. The present exercise should lay the ground, nevertheless, for studying the emissions fares a multidivisional firm's subsidiaries subject to different fiscal regimes and adjusting via transfer pricing will respectively face.[5] Preliminary developments in the presence of emissions taxes can be found in Section 6.

A third area is environmental taxation in the presence of other taxes (see, e.g., Bovenberg and de Mooij, 1994; Bovenberg and Goulder, 1996; Fullerton and Metcalf, 2001; Lai, 2013). Previous studies have considered the impact of (distortionary) labor and capital taxes on optimal pollution taxes, while modelling the firm as a production function. In this paper, the firm is a vertical structure, and local carbon fares are applied in the presence of taxes on profits.

This paper finally stands at the junction of the literatures on greening global value chains (e.g., Sinclair-Desgagné, 2013), transboundary pollution (e.g., Copeland, 1996; Missfeldt, 1999), international environmental agreements and climate change policies (e.g., Marrouch and Chaudhuri, 2016; Ritz, 2022), environmental federalism (e.g., Oates, 2001; Percival, 1995), local policy choices (Agrawal et al., 2022), and the diffusion of local regulations (e.g. Hale and Urpelainen, 2015). For tractability and clarity reasons, we overlook cross-border tariffs and strategic interactions between countries. Our analysis rather fits the situation of countries forming a free-trade zone; it would apply as well to a federal state or a group of cities. Throughout the paper we shall thus speak of multidivisional instead of multi- or trans- national firms. The aim is to clearly highlight yet another channel - transfer pricing - by which environmental measures in one jurisdiction can impact production and emissions in other jurisdictions.

The paper unfolds as follows. Section 2 develops the model. This model is put to work in section 3, where we show in general how emissions farees would be incorporated into transfer prices, along with taxes on profits. Section 4 explores the impact of such transfer prices on the subsidiaries' respective production and polluting emissions, under various fiscal scenarios. Section 5 discusses the diffusion of local emissions farees across jurisdictions, owing to the multidivisional firm's internal carbon pricing. Section 6 introduces

[5]The term 'fare' can either refer to a direct tax implemented by an authority, a quoted price on an emissions market, or a price resulting from a voluntary agreement between a government and a firm.

two extensions to the model. First, we briefly consider the situation when jurisdictions impose emissions taxes and look at them at the equilibrium. Then, we reconsiders internal carbon pricing when subsidiaries can invest in pollution abatement. Section 7 contains concluding remarks.

2 The model

Consider a multidividional firm made of two subsidiaries or divisions. The upstream one U - the 'producer' - delivers a quantity q of an intermediate good at a unit cost c. This good is shipped to the downstream division D - the 'seller' - at a pre-established transfer price τ per unit.

We assume that the upstream subsidiary is not subject to a capacity constraint and produces only for the upstream division. Each unit of the intermediate good generates z_U units of emissions, so the producer's total emissions are given by $e_U = z_U \cdot q$. Let the jurisdiction in which the upstream subsidiary operates apply a tax s_U on profit and a fare t_U on polluting emissions. The producer's after-tax profit function π_U in this case is given by

$$\pi_U = (1 - s_U) \cdot [\tau - c - T_U] \cdot q, \tag{1}$$

where $T_U = z_U \cdot t_U$ stands for the upstream division's carbon fee.

The downstream subsidiary uses one unit of the intermediate good to supply one unit of the final good with constant marginal cost normalized at 0. It is a local monopoly in its jurisdiction, facing the linear inverse demand function $p(q) = a - q$. Its activities (assembly, delivery, consumer services) also generate polluting emissions at rate z_D, so the overall pollution from selling q items is given by $e_D = z_D \cdot q$. Let the downstream jurisdiction tax profit at rate s_D and apply a carbon fare at rate t_D respectively. The seller's after-tax profit function π_D can be written as follows

$$\pi_D = (1 - s_D) \cdot [a - q - \tau - T_D] \cdot q \tag{2}$$

Figure 1: The decisions timeline

where $T_D = z_D \cdot t_D$ is the downstream subsidiary's carbon fee.

The multidivisional firm's overall after-tax profit function π is the sum of each division's after-tax profits, that is

$$\pi = (1 - s_D) \cdot [a - q - \tau - T_D] \cdot q + (1 - s_U) \cdot [\tau - c - T_U] \cdot q \tag{3}$$

As long as taxes on profit are different across jurisdictions, the transfer price τ will appear in the expression for π, hence figure explicitly as another decision variable in profit maximization.[6]

The various outcomes to be considered below will be assumed to follow the timeline depicted in Fig. 1: taking each jurisdiction's respective profit tax s_D , s_U (or fiscal policy) and fare t_D, t_U on emissions (or environmental policy) as given, the multidivisional firm sets the transfer price τ, and the downstream subsidiary then selects the quantity q to be ordered from the upstream manufacturing division; the firm and its divisions finally receive their respective profits π, π_D , π_U. Using backward induction, our analysis will start by computing the seller's selected quantity $q(\tau)$, then proceed with deriving the firm's optimal transfer price under given emissions fares and profit taxes.

3 Green transfer pricing - A general result

To begin with, let's consider, as a benchmark case, the customary situation where there are positive but different taxes on profit and no fares on polluting emissions, i.e. $s_D \neq s_U$ and $t_U = t_D = 0$.

[6]This is a simplified account of how transfer pricing goes within multidivisional enterprises. For additional precisions, see the document from the OECD (2017) cited in the bibliography.

The seller's optimal quantity at transfer price τ should satisfy the first-order condition[7]

$$\frac{\partial \pi_D}{\partial q}\Big|_{t_D=0} = (1-s_D)\cdot(a-2q-\tau)=0 \ ,$$

which implies that $\overline{q} = \frac{a-\tau}{2}$. Taking this behavior into account, the multidivisional firm will in turn set a transfer price that meets the first-order condition

$$\frac{\partial \pi}{\partial \tau}\Big|_{t_D=0} = \frac{\tau[(1-s_D)-2(1-s_U)]}{2} - \frac{(1-s_D)a-(1-s_U)(a+c)}{2} = 0$$

Doing some algebra yields the following output and internal pricing expressions

$$\begin{cases} \overline{\tau} = \dfrac{(1-s_D)a-(1-s_U)(a+c)}{(1-s_D)-2(1-s_U)} \\ \overline{q} = \dfrac{a-\overline{\tau}}{2} = \dfrac{(1-s_U)(c-a)}{2(1-s_D)-4(1-s_U)} \end{cases} \tag{4}$$

One upshot of this exercise is that, since $\frac{\partial \overline{\tau}}{\partial s_D} > 0$, an increase of the tax on profit imposed by the downstream jurisdiction leads the multidivisional firm to raise its transfer price; on the other hand, since $\frac{\partial \overline{\tau}}{\partial s_U} < 0$, an increase of the tax on profit occurring in the upstream jurisdiction makes the firm decrease τ. This is consistent with one of the main prediction of the transfer pricing literature: the multidivisional firm uses transfer prices to shift revenue from high-taxes to low-taxes jurisdictions, thereby increasing its overall after-tax profit (Clausing, 2003; Cristea & Nguyen, 2016; Davies et al., 2018).

Suppose now that, in addition to taxing business profits, each jurisdiction raises a fare on polluting emissions.

Using expression (2), the first-order condition for the seller's quantity order is now

$$\frac{\partial \pi_D}{\partial q} = (1-s_D)\cdot(a-2q-\tau-T_D)=0 \ ,$$

[7]Throughout this paper, we assume that all solutions to the first-order conditions are interior to their domain.

and the firm's optimal transfer price must then satisfy the first-order condition

$$\frac{\partial \pi}{\partial \tau} = [(1 - s_D) - (1 - s_U)] \cdot \frac{a - \tau - T_D}{2} - (1 - s_U) \cdot \frac{\tau - c - T_D}{2} = 0$$

The latter equations yield the following production and transfer pricing formulas:

$$\begin{cases} \tau^* = \overline{\tau} + \dfrac{(1 - s_U)(T_D - T_U) - (1 - s_D)T_U}{(1 - s_D) - 2(1 - s_U)} = \overline{\tau} + \dfrac{(s_D - s_U)T_D - (1 - s_U).T_U}{(1 - s_D) - 2(1 - s_U)} \\ q^* = \overline{q} + \dfrac{1}{2} \cdot \dfrac{(1 - s_U)(T_D + T_U)}{(1 - s_D) - 2(1 - s_U)} \end{cases} \tag{5}$$

Through their respective right-hand term, the latter expressions highlight the corrections that transfer prices and quantity orders will respectively incur, as the multidivisional firm wants its transfer pricing to internalize the regulators' emissions fares. This is the central result of this paper.

Theorem. *Internal carbon pricing by the multidivisional firm leads to amend its current transfer prices according to formula (5), i.e. by adding these prices a weighted sum of the jurisdictions' emissions fares. The weights are functions of the jurisdictions' respective tax rate on profit.*

In accordance with the quotes at the beginning of this paper, one can see here that emissions fares only imperfectly regulate the multidivisional firm's subsidiaries. The latter will rather behave according to the internal transfer prices they face. Whether these transfer prices, so the firm's ensuing production and total emissions, should go up or down depends not only on the social costs of pollution (which market emissions fares should somehow reflect), but also on the fiscal context which the multidivisional firm is facing.[8] The upcoming section will now look at what will happen under specific fiscal scenarios.

[8]The literature on the social cost of carbon has also developed on other external determinants such as GDP (Withagen, 2022) and risk (Taconet et al., 2021).

4 Fiscal scenarios

From the general formula (5), one cannot infer a definite relationship between carbon fares, transfer prices, the firm's production and total polluting emissions. Much actually depends on the jurisdictions' respective/relative fiscal policy, hence on the absolute rates s_D, s_U , and their divergence. This section will successively consider the three possible scenarios: (i) when profit taxes are the same across jurisdictions ($s_D = s_U$), (ii) when the seller's jurisdiction imposes relatively higher taxes on profit ($s_D > s_U$), and (iii) when a relatively more stringent fiscal policy holds in the producer's jurisdiction ($s_D < s_U$).

4.1 Both jurisdictions are fiscally similar

When $s_D = s_U$, formula (5) predicts that the multidivisional firm will set the transfer price at $\tau^* = \overline{\tau} + T_U$. The upstream jurisdiction's carbon fare T_U is then passed on entirely to the downstream subsidiary via τ^*. In other words, the selling division, which decides on the firm's output, will internalize the producer's emissions fare. This is consistent with a pure 'cost-based transfer pricing approach' (see, e.g., Hirshleifer 1956). It also corroborates some organizational practices regarding internal carbon pricing: when discrepancies in the fiscal landscape of the multidivisional firm are not taken into account, one way to go with ICP is to enforce on the firm's subsidiaries a fee based on the social cost of carbon (as Microsoft actually did).[9] The following proposition underscores this result.

Proposition 1. *When profit tax rates are equal across jurisdictions, the firm's internal carbon price is the upstream jurisdiction's emissions fare.*

The upshot is that the downstream subsidiary's ordered quantity q^* will internalize the carbon fares over the entire vertical structure, since this subsidiary is also subject to

[9]There are two main methods to set an internal carbon price: shadow pricing and carbon fee. Shadow pricing consists in applying an internal carbon price to the company's investments, whereas a carbon fee is directly enforced on the subsidiaries' transactions to incentivize a change in their practices. For a detailed review of internal carbon pricing approaches, the reader is referred to Gorbach et al. (2022).

the emissions fare T_D in its own jurisdiction; indeed, we have $q^* = \overline{q} - \frac{1}{2}(T_D + T_U)$.[10] This internal carbon pricing entails, furthermore, that the derivatives $\frac{\partial e_i^*}{\partial t_j} = -\frac{1}{2} \cdot z_i^2 < 0$ and $\frac{\partial e_i^*}{\partial t_i} = -\frac{1}{2} \cdot z_i \cdot z_j < 0$ for $i, j = U, D$: a higher carbon fare in *any* jurisdiction will thus lead to lower polluting emissions throughout the firm's supply chain.

4.2 The downstream jurisdiction is fiscally more stringent

Consider now the situation where $s_D > s_U$, so the seller's profits are taxed more heavily than the producer's ones in their respective jurisdictions.[11]

In this case, the firm's internal price of carbon, which is formula (5)'s correction term for the benchmark transfer price $\overline{\tau}$, has a negative denominator $(1 - s_D) - 2(1 - s_U)$. This term's numerator has two components. One is the upstream jurisdiction's carbon fee T_U multiplied by a negative factor $-(1 - s_U)$. As in the previous case, the firm thereby makes the seller internalize (yet partially, here) the carbon fare imposed on the producer. This scheme, however, is now tempered by the numerator's other component, $(s_D - s_U) \cdot T_D$, which is positive. The latter takes into account the fiscal gap $(s_D - s_U)$ between the two jurisdictions and the downstream jurisdiction's carbon fee T_D. With this second component, the firm has the fiscally-advantaged producer 'subsidize', so to speak, the 'overtaxed' seller by pushing down the former's revenue per unit made and shipped. This has two effects: first, it avoids having the seller reduce too much its quantity order in response to the emissions fares; second, the producer thereby internalizes the carbon fare set on the seller in proportion to its fiscal advantage. If the fiscal gap $(s_D - s_U)$ times the emissions fee T_D is big enough compared with $(1 - s_U) \cdot T_U$ (a trivial case being $T_U = 0$, so there is no fare on emissions in the upstream jurisdiction), the correction term

[10] This specific form for the correction term - i.e. $\frac{1}{2}(T_D + T_U)$ - is due to our assumptions that demand is linear and the downstream division is a monopoly. A different term would have appeared under more general specifications (Weyl & Fabinger, 2013), but our qualitative conclusions would still hold.

[11] This is the most common situation. For example, in their latest environmental strategy report, Renault Group - a French company operating in the car industry - stated they will engage the supply chain by implementing an internal carbon price (Renault Group, 2021). One of her downstream subsidiaries is Dacia Group, which sells self-branded cars in France. The upstream subsidiaries of Renault Group producing Dacia cars are based in Romania and Morocco. Romania is taxing less than France, and Morocco does not always apply a profit tax thanks to its industrial policy.

will turn negative, rendering the resulting transfer price τ^* *smaller* than the benchmark one $\overline{\tau}$. This discussion is summarized in the following proposition.

Proposition 2. *When the downstream jurisdiction applies a higher tax rate on profit, the firm's internal carbon price is proportional to the producer's carbon fare minus an adjustment for the producer's tax advantage. The internal carbon price will be negative if this adjustment - being the difference between profit taxation rates times the downstream jurisdiction's carbon fee - is big enough.*

As formula (5) shows, however, whatever the transfer price, the qualitative effect of a larger carbon fare in *any* jurisdiction is still to bring all subsidiaries' emissions down since $\frac{\partial e_i^*}{\partial t_i} = \frac{1}{2} \cdot \frac{(1-s_U)}{(1-s_D)-2(1-s_U)} \cdot z_i^2 < 0$ and $\frac{\partial e_i^*}{\partial t_j} = \frac{1}{2} \cdot \frac{(1-s_U)}{(1-s_D)-2(1-s_U)} \cdot z_i \cdot z_j < 0$ for $i, j = U, D$. All things equal, though, a larger fiscal gap $(s_D - s_U)$ will pull these derivatives down, so carbon fares should be less effective to curb emissions.

4.3 The upstream jurisdiction is fiscally more stringent

Finally, let $s_D < s_U$, so it is now the producer which faces higher taxes on profits.

In this case, the numerator in formula (5)'s correction term, $(s_D - s_U)T_D - (1-s_U) \cdot T_U$, is negative, but the sign of the denominator, $(1 - s_D) - 2(1 - s_U)$, is ambiguous. We have that $(1 - s_D) - 2(1 - s_U) < 0$ whenever $s_U < \frac{1}{2}(1 + s_D)$, i.e. when the fiscal gap $(s_U - s_D)$ is 'not too big'; in this case, the internal carbon price is positive, so the seller still partly internalizes the producer's carbon fare (while having its own emissions fare weigh more on its decision). In the opposite case $s_U > \frac{1}{2}(1 + s_D)$, however, the magnitude of the gap $(s_U - s_D)$ leads fiscal arbitrage to prevail over environmental considerations: the firm then sets a negative internal carbon price, thereby shifting as much of the tax burden as possible to the producer in order to decrease the latter's profit (while this will not affect the production decision). These findings support a third proposition.

Proposition 3. *When the upstream jurisdiction's tax rate on profit is greater, the firm's internal carbon price is proportional to the two jurisdictions' carbon fares. It is positive if and only if* $s_U < \frac{1}{2}(1 + s_D)$*, i.e. the fiscal gap* $(s_U - s_D)$ *is not too big.*

This time, due to fiscal arbitrage, the impact of carbon fares on the firm's production and total emissions is not straightforward. When $s_U < \frac{1}{2}(1 + s_D)$, so the jurisdictions fiscal divergence is moderate, the expected relationship holds: increasing carbon fares in *any* jurisdiction entails a decrease in polluting emissions. When $s_U > \frac{1}{2}(1+s_D)$, however, greater production and more polluting emissions will result if some jurisdiction raises its carbon fare. Empirically speaking, this outcome might be rare, for the downstream subsidiaries of multidivisional firms tend to locate in wealthy areas (see Meng et al., 2020; Mudambi, 2008), and environmental regulation in these locations is typically more stringent and effective (see Dinda, 2004, and the literature on the environmental Kuznets curve). Yet, our model highlights a correlation between fiscal discrepancies and environmental degradation (see also Galaz et al., 2018). It thus provides an additional (perhaps surprising) rationale - i.e., environmental policy effectiveness - for coordinating fiscal and environmental policies (see also Liu, 2013), and for fostering fiscal harmonization (as intended by the recent OECD International Tax Agreement).

5 The diffusion of local environmental regulations

The previous results suggest that a multidivisional firm's deployment of transfer prices to manage its production and emissions can make local environmental policies resonate across jurisdictions. Having a closer look at the sensitivity of internal carbon prices with respect to emissions fares and the fiscal gap reveals that $\frac{\partial^2 \tau^*}{\partial \Delta s . \partial t_i} > 0$ for all $\Delta s = s_D - s_U$, $i = U, D$. In words: as the fiscal gap gets larger, the sensitivity of transfer prices to a change in the emissions fare implemented in *any* jurisdiction goes up. This yields the following proposition.

Proposition 4. *As the difference between fiscal regimes grows, so does the sensitivity of internal carbon prices to emissions fares.*

Stated differently: thanks to internal carbon pricing, an emissions fare amendment imposed on the producer (seller) has an incidence on the seller (producer) which augments with the fiscal gap. Again, multidivisional firms routinely use transfer pricing for tax shifting purposes (Göx & Schiller, 2006). In response, local governments act strategically to attract and retain firms.[12] This discussion now highlights the further role of transfer pricing (modulated by fiscal regimes) in allocating the burden of emissions fares across jurisdictions.

Turning to emissions, we then find that $\frac{\partial^2 e_i^*}{\partial \Delta s . \partial t_j} < 0$ for all $\Delta s = s_D - s_U$, $i, j = U, D$ and $i \neq j$. This supports another proposition.

Proposition 5. *As the difference between fiscal regimes goes down, a change in the emissions fare applied to the seller (producer) will affect the producer's (seller's) emissions to a greater extent.*

This statement conveys a two-fold conclusion. A given jurisdiction's emissions fare will not only impact the targeted subsidiary's pollution, it will also affect that of the subsidiary located in the other jurisdiction. Again, the magnitude of the latter is contingent on the actual fiscal context that the multidivisional firm is facing.

These findings have implications for global environmental governance and environmental federalism.[13]

Since GHG emissions have the same impact on global warming wherever they come from, a common approach to regulate them seeks to engage as many national jurisdic-

[12] The research on the interdependence of local tax policies is summarized in Agrawal et al. (2022).

[13] Environmental federalism considers what is the appropriate level of action (federal vs state vs city, say) to regulate environmental externalities. In the case of local pollution, such as noise or smog, it should be up to local jurisdictions to regulate. Cooperation between neighboring jurisdictions is of course an asset when an effluent can flow into another jurisdiction. For greenhouse gases, which environmental impact is global, higher governing bodies are usually called upon. For a literature survey on environmental federalism, the reader is referred to Oates (2001).

tions as possible. But while there are success stories in multilateral commitment (e.g., the 1987 Montreal Protocol on substances that deplete the ozone layer), reaching a global consensus on how to abate emissions has proved so far to be hardly achievable. Scholars have suggested two possible approaches to tackle this issue so far. On one hand, one could rely basically on 'coalitions of the willing' and the creation of 'climate clubs', i.e. some relatively small coalitions of jurisdictions which possibly impose penalties (notably trade costs) on outsiders (Nordhaus, 2019). But abating GHG emissions faces a prisoner's dilemma, so the number of engaged parties would negatively affect the effectiveness of an agreement due to potential free-riding behavior by participants (Barrett, 1994). This suggests a 'race-to the bottom' (e.g. Wellisch, 2000; Wilson, 1996); the fact that the production of pollution-intensive goods could move to 'pollution havens' where environmental policies are more permissive (Candau et al., 2017; Grether et al., 2012) might encourage certain jurisdictions to lower their environmental standards in order to attract investments.[14] One way to elude such a setback, according to our analysis, would be to foster coalitions covering the most central nodes of global value chains. The corresponding subsidiaries' compliance with climate policies would then have the largest impact on the abatement and emissions of the other subsidiaries located in non-participating jurisdictions. Recent efforts to implement the Paris agreement on climate change seem to be moving in this direction. At the COP26, in Glasgow, decisions were made to target the five most pollution-intensive industries - energy, land transportation, steel, agriculture and hydrogen, with commitments made by small-scale industry-specific coalitions of key governments and businesses (Ghosh et al., 2022).

The occurrence of climate coalitions will likely entail discrepancies across countries in market carbon pricing. In a recent article, Ritz (2022) provided a rationale for this state of affairs when there is international trade, firm heterogeneity and market power. This paper's results suggest that carbon price discrepancies should hold, furthermore, within global value chains, due notably to differences in fiscal regimes.

[14]'Races to the top' have been observed in some cases, though (see, e.g., List and Gerking, 2000; Millimet, 2003).

6 Extensions

This section will draw on the previous model to develop two extensions. First, the peculiar situation when both jurisdictions implement a carbon tax is succinctly studied. This exercise allows us to determine the emissions taxes at the equilibrium and provides policy implications. Abatement efforts from both divisions are then introduced, which highlights recommendations for organizational practices.

6.1 Equilibrium emissions taxes

This section builds on the most common fiscal situation, which is when $s_D > s_U$ (so profit is taxed more heavily in the seller's jurisdiction).

Let both jurisdictions implement an emissions tax without cooperation. Assume that all regulators are benevolent, so they seek to maximize social welfare. In the upstream jurisdiction, the regulator's total revenue is $TR_U = s_U \cdot \frac{\pi_U}{1-s_U} + T_U \cdot q$, the producer's surplus is equal to π_U, the local consumer surplus is zero since all that is produced goes to the upstream division, and the environmental damage is given by $ED_U = \frac{1}{2} \cdot e_U^2$. The upstream regulator's social welfare function is thus given by

$$\begin{aligned} W_U = \pi_U + TR_U - ED_U \\ \Leftrightarrow W_U = (\tau - c) \cdot q - \frac{1}{2} \cdot z_U^2 \cdot q^2 \end{aligned} \tag{6}$$

In the downstream jurisdiction, the regulator's total revenue is $TR_D = s_D \cdot \frac{\pi_D}{1-s_D} + T_D \cdot q$, the seller's surplus is its profit π_D, the environmental damage is $ED_D = \frac{1}{2} \cdot e_D^2$, and the consumer surplus is given by

$$CS = \int_0^q [P(Q) - P(q)] \cdot dQ = \frac{1}{2} \cdot q^2$$

The downstream regulators' social welfare function can then be written as

$$\begin{aligned} W_D = \pi_D + TR_D + CS - ED_D \\ \Leftrightarrow W_D = (a - q - \tau) \cdot q + \frac{1}{2} \cdot q^2 - \frac{1}{2} \cdot z_D^2 \cdot q^2 \end{aligned} \tag{7}$$

When an internal carbon price applies through the value chain, the upstream and downstream regulators will mutually adjust their emissions tax according to the respective reaction functions

$$\begin{cases} t_U = R_U(t_D) = \dfrac{2(1-s_D)-(2-z_U^2)(1-s_U)}{z_U^3(1-s_U)}(a-c) + \dfrac{2(s_D-s_U)-z_U(1-s_U)}{z_U^2(1-s_U)} \cdot z_D \cdot t_D \\ t_D = R_D(t_U) = \dfrac{[(1+z_D^2)(1-s_U)-2(s_D-s_U)](a-c)-4(1-s_U)a}{4z_D(s_D-s_U)+z_D(1+z_D^2)(1-s_U)} \\ \qquad\qquad - \dfrac{2(s_D-s_U)+(1+z_D^2)(1-s_U)}{4z_D(s_D-s_U)+z_D(1+z_D^2)(1-s_U)} \cdot z_U \cdot t_U \end{cases} \tag{8}$$

At equilibrium (where these reaction functions meet), the upstream and downstream emissions taxes are respectively

$$\begin{cases} t_U^* = \dfrac{[(1-s_D)-2(1-s_U)][2(s_D-s_U)(a-2c)-(1-s_U)(z_U^2 a+(1+z_D^2))c)]}{z_U[1+2s_D+z_D^2+z_U^2-s_U(3+z_D^2+z_U^2)](s_D-s_U)} \\ \qquad - \dfrac{(s_D-s_U)(2a-c)+(1-s_U)c}{z_U(s_D-s_U)} \\ t_D^* = \dfrac{[1+2s_D+z_D^2-s_U(3+z_D^2)](s_D-s_U)-z_U^2(1-s_U)^2}{z_D[1+2s_D+z_D^2+z_U^2-s_U(3+z_D^2+z_U^2)](s_D-s_U)}(c-a) \end{cases} \tag{9}$$

From these expressions, one may conclude that taking global value chains and their internal carbon prices into account in setting carbon fares would make the latter differ across countries. This further corroborates the conclusion that Ritz (2022) had already reached after considering other contextual features (i.e. international trade, firm heterogeneity, and market power).

6.2 Abatement effort

A widely-held purpose for implementing ICP is that it should enhance abatement efforts and cleaner technology investments.[15] To investigate this point, let's assume that each subsidiary $i = U, D$ can expend an effort r_i at a cost $\frac{1}{2}\gamma \cdot r_i^2$ to reduce its emissions by $R_i =$

[15] It is common wisdom that environmental regulation in general should encourage innovative activities in the targetted firms. For a survey on the matter, the reader may consult Dechezleprêtre and Sato (2017). For empirical evidence corroborating this assertion, see for instance Aghion et al. (2016) and Jaffe and Palmer (1997). Using firm-level data from the auto industry, the former found that higher taxes on fuel prices induce initiatives to develop cleaner technologies. The latter showed that higher R&D expenditures are triggered by higher pollution-control expenditures (which is a proxy for more stringent environmental regulation).

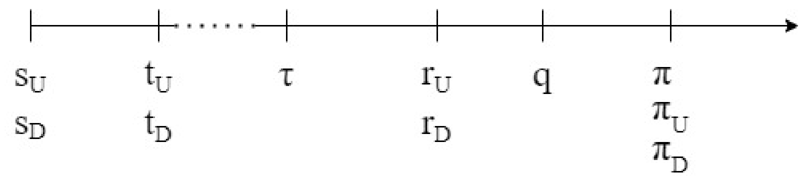

Figure 2: The timing of abatement efforts

$r_i \cdot q$. The quadratic cost function captures decreasing returns to effort. For tractability reasons, we suppose that the positive parameter γ is the same across subsidiaries, and that the endogenous values r_i^2, $i = U, D$, fall within the interval $[0, 2\gamma)$. Figure 2 describes the actual timing of abatement efforts in the multidivisional firm: investments in cleaner technology happen simultaneously in both divisions, ahead of production decisions. The downstream and upstream subsidiaries' after-tax profit functions are now respectively

$$\begin{cases} \pi_{D,R} = (1 - s_D) \cdot [(a - q - \tau)q - t_D(z_D - r_D)q - \dfrac{1}{2}\gamma \cdot r_D^2] \\ \pi_{U,R} = (1 - s_U) \cdot [(\tau - c)q - t_U(z_U - r_U)q - \dfrac{1}{2}\gamma \cdot r_U^2] \end{cases} \tag{10}$$

When there are no fares on emissions, we naturally have $r_U = r_D = 0$, while the transfer price and the quantity delivered are again respectively $\overline{\tau}_R = \overline{\tau}$ and $\overline{q}_R = \overline{q}$.

In the presence of emissions fares, however, production is set at

$$q_R^* = (1 + \frac{t_D^2}{2\gamma - t_D^2}).\frac{a - \tau - T_D}{2} \ , \tag{11}$$

and the downstream and upstream subsidiaries respectively contribute the following investments to abate CO_2 emissions:

$$\begin{cases} r_D^* = \dfrac{2t_D}{2\gamma - t_D^2} \cdot \dfrac{a - \tau - T_D}{2} \\ r_U^* = \dfrac{t_U}{\gamma}(1 + \dfrac{2t_D}{2\gamma - t_D^2}) \cdot \dfrac{a - \tau - T_D}{2} \end{cases} \tag{12}$$

From (12), one can readily infer that the producer's and the seller's respective efforts will be coordinated through the transfer price. If $t_U \geqq \gamma$ or the emissions fare in the upstream jurisdiction is larger than the slope of the marginal cost of abatement, moreover, this model predicts that $r_U^* > r_D^*$. The latter inequality holds whatever the emissions fare implemented downstream. We underline this finding through a proposition.

Proposition 6. *Suppose that a fare is applied to emissions in both jurisdictions. Then, if the emissions fare imposed upstream is large enough, the producer will always invest more in abatement than the seller.*

Meeting the first-order condition for profit maximization now yields the following production and transfer pricing formulas:

$$\begin{cases} \tau_R^* = \dfrac{(1-s_D)a-(1-s_U)[(1-\upsilon)a+c]}{(1-s_D)-(2-\upsilon)(1-s_U)} + \dfrac{(1-s_U)[(1-\upsilon)T_D-T_U]-(1-s_D)T_D}{(1-s_D)-(2-\upsilon)(1-s_U)} \\ q_R^* = \beta \cdot \left[\dfrac{(1-s_U)[c-(1-\upsilon)a]}{(1-s_D)-(2-\upsilon)(1-s_U)} + \dfrac{(1-s_U)[(1-\upsilon)T_D+T_U]}{(1-s_D)-(2-\upsilon)(1-s_U)}\right] \end{cases} \tag{13}$$

where $\beta = \frac{\gamma}{2\gamma - t_D^2}$ and $\upsilon = \frac{t_U.(2-t_U)}{2\gamma - t_D^2}$. Comparing (13) with (5), a primary difference is the inclusion of the term υ - which depends on the emissions fares and the abatement cost parameter - in the benchmark transfer price $\overline{\tau}$. This yields our next proposition.

Proposition 7. *Suppose that a fare is applied to emissions in both jurisdictions. Then, when the firm's subsidiaries can invest in pollution abatement, internal carbon pricing does not make for a separate component of the transfer price.*

This result has organizational ramifications. In most firms, fiscal and environmental matters are usually handled by specialized employees working in distinct business units. Expression (5) allows these employees to work separately: on the one hand, tax accountants would set the internal price $\overline{\tau}$ based on current profit taxes; on the other hand, people implementing the firm's environmental strategy might add an internal carbon price based on profit and emissions fares; both prices would then combine into the green transfer price τ^*. When the firm's subsidiaries can invest in pollution abatement, however, tax accountants dealing with transfer pricing must take into account the environmental policy which holds in each jurisdiction. Some information transfer from the environmental strategists to the firm's fiscal compliance unit is thus necessary.

From expression (13), one cannot assume clear-cut fiscal scenarios to infer monotone relationships between carbon fares, transfer prices, the quantity produced and total polluting emissions. Yet, doing some algebra, we obtain formulas that look more similar to the ones in (4)-(5) above.

$$\begin{aligned}\tau_R^* =& \frac{(1-s_D)a-(1-s_U)(a+c)}{(1-s_D)-(2-\upsilon)(1-s_U)} + \frac{(s_D-s_U)T_D-(1-s_U)T_U}{(1-s_D)-(2-\upsilon)(1-s_U)} \\ &+ \frac{\upsilon(1-s_U)(a-T_D)}{(1-s_D)-(2-\upsilon)(1-s_U)}\end{aligned} \tag{14}$$

and

$$\begin{aligned}q_R^* =& \beta\cdot\left[\frac{(1-s_U)[c-a]}{(1-s_D)-(2-\upsilon)(1-s_U)} + \frac{(1-s_U)[T_D+T_U]}{(1-s_D)-(2-\upsilon)(1-s_U)}\right] \\ &+ \beta\cdot\frac{\upsilon(1-s_U)(a-T_D)}{(1-s_D)-(2-\upsilon)(1-s_U)}\end{aligned} \tag{15}$$

When these formulas' common denominator $(1-s_D)-(2-\upsilon)(1-s_U)$ is positive while $0<\upsilon<2$, we have that $\tau_R^*>\tau^*$ and $q_R^*>q^*$. This brings forth a last proposition.

Proposition 8. *Suppose that a fare is applied to emissions in both jurisdictions. Under certain profit and emissions fares configurations, allowing the firm's subsidiaries to invest in cleaner technologies can lead to both higher transfer prices and greater production.*

Proposition 8 exhibits a situation in which the producer's profit would go further up as a consequence of environmental policy. This case agrees with some empirical works in relation with the Porter hypothesis,[16] which highlighted the spillovers from a regulated downstream subsidiary on an upstream division's innovation and productivity (see, e.g., Greaker and Rosendahl, 2008; Leiter et al., 2011). We single out here another channel - green transfer prices - through which this might happen.

[16]For an initial statement of the Porter Hypothesis, the reader is referred to Porter and Van der Linde (1995)'s seminal article. Different versions of the hypothesis are discussed in Jaffe and Palmer (1997).

7 Conclusion

This paper considered internal carbon pricing (ICP), a modus operandi which is spreading fast across multidivisional firms and global value chains to curb greenhouse-gases emissions. Our analysis revealed that: (i) along with the emissions fare imposed in each jurisdiction, the taxes set on the subsidiaries' respective profits also matter in establishing internal carbon prices, (ii) through ICP, an emissions fare aimed at a given subsidiary has an incidence on other subsidiaries not subject to such a fare, (iii) allowing the firm's divisions to invest in pollution abatement raises the need to coordinate tax accounting with environmental strategy.

The above model relied of course on several key assumptions. First, we linked ICP to the general and well-established practice of transfer pricing. This is in line with the prescriptions of management practitioners. According to the Global Compact Network Germany (2018, p. 2), for instance, "carbon pricing within a company can only have real impact when it gains genuine recognition in the decision-making process and is integrated into internal structures and processes.". Second, emissions fares were implemented and they proved essential to come up with internal carbon prices. Other environmental policy intruments might have been deployed, of course (e.g., emissions standards, subsidies, voluntary approaches); and there exist other approaches to ICP, using energy taxes or renewable energy support tariffs for instance (Ecofys et al., 2017). Considering these various cases would constitute significant extensions. Third, we ignored international trade costs. But organizations that use transfer pricing often operate in an international context (Antràs & Chor, 2022). Introducing tariffs and other border adjustment mechanisms would be welcome at this point. Fourth, the above model corresponds to a vertically integrated monopoly. In real life, however, market competition weighs crucially on the internal efficiency of vertical supply chains (see for instance Arya and Mittendorf, 2007). Further research might thus analyze the role of competitiveness considerations in green transfer pricing. Finally, our inquiry employed a simple (two-level) and fixed organizational structure. One next step would be to examine the nature and strength of the interaction between ICP and different organizational structures.

Substantial applied research has already been devoted to the use of transfer pricing as a corporate fiscal instrument (e.g. Göx and Schiller, 2006), and business organizations have followed up in implementing transfer pricing policies accordingly (OECD, 2017). The ultimate challenge is to now convey policymakers and transfer pricing practitioners the rigorous background and appropriate tools to make transfer prices greener.

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