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International trade and corporate environmental responsibility

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Abstract

We investigate corporate environmental responsibility (CER) in the context of international trade and emission permit competition between two countries. Our analysis reveals that CER does not affect the issuance of emission permits or the resulting emissions in these countries. However, a higher level of CER enhances firms' private profits. These findings suggest that firms may adopt CER voluntarily to increase their profitability.

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1 Introduction

The rapid increase in carbon emissions over the past century has resulted in numerous environmental catastrophes worldwide. To mitigate carbon emissions, many governments have implemented environmental regulations, such as emission permits and taxes, on the production of their firms. Firms, in turn, adjust their production to reduce emissions and maximize their private profits. Recently, however, there has been a notable shift toward corporate environmental responsibility (CER), with more firms voluntarily incorporating environmental considerations into their decision-making processes. For instance, Coca-Cola has committed to reducing its absolute greenhouse gas emissions by 25% by 2030 and achieving net-zero carbon emissions by 2050.

While CER has been extensively studied in the closed economy, e.g., Liu et al. (2015), Fukuda and Ouchida (2020), Hirose et al. (2020), Hirose and Matsumura (2022), Xu et al. (2022), Tomoda and Ouchida (2023), Xing and Lee (2024), its impact in the context of international trade remains underexplored. Particularly, most previous papers have identified a pollution-reducing effect of CER in a closed economy, but it remains unclear whether this effect persists in an open economy.

To our knowledge, only Yanase (2012), Jinji (2013), Bárcena-Ruiz and Sagasta (2022, 2024) and Cheng et al. (2025) have examined CER within the framework of international trade. However, it has not been thoroughly investigated how CER firms react to different levels of emission permits across countries and how CER affects countries' issuance of emission permits. We address these questions in this study.

In contrast to the oligopoly models commonly adopted in the CER literature, we employ a monopolistic competition model. This model is well-suited for capturing the characteristics of some polluting industries that produce differentiated goods, such as the chemical industry. Additionally, as highlighted by Konishi and Tarui (2015), even seemingly homogeneous polluting industries have progressively evolved into industries producing differentiated goods, as evidenced by significant intra-industry trade. Examples of such industries include ceramics, ferrous metals, and nonferrous metals. Moreover, our study distinguishes itself by examining both emission permits and taxes, whereas previous CER papers have predominantly focused on emission taxes alone.[1] Our objective is to present alternative perspectives for analyzing CER.

The remainder of this paper is organized as follows. Section 2 introduces the basic model. In Section 3, we investigate emission permit competition. Section 4 discusses emission tax competition and some assumptions of our model. Section 5 concludes the paper.

2 Basic model

There are two countries, Home and Foreign, denoted by H and F, respectively. Each country has a representative individual, consuming two types of goods: clean goods and manufactured goods. Clean goods are the numéraire. They are homogeneous, traded without trade

[1] According to the Carbon Pricing Dashboard of the World Bank, emissions trading systems covered 17.55% of annual global greenhouse gas emissions in 2022, whereas carbon taxes covered only 5.62% of them. This highlights the significance of emissions trading or emission permits.

costs, and produced under constant returns to scale and perfect competition, with each unit production requiring one unit of labor. These assumptions ensure that the prices of clean goods are the same in both countries and equal to the domestic wages rates, which are all normalized to one for simplicity. In the manufacturing sector, there are a continuum of firms in a unit interval $[0, 1]$, with each firm producing a distinct variety of manufactured goods. These goods generate carbon emissions during their production, which causes environmental damage and harms the individuals. They are subject to the Dixit–Stiglitz type of monopolistic competition and traded without costs.[2] The representative individual in Home has a quasi-linear utility function:

$$U^H = \mu \ln M^H + A^H - \gamma E^G, \tag{1}$$

where

$$M^H \equiv \left[\int_0^1 \left(x_i^{HH}\right)^{1-\frac{1}{\sigma}} \mathrm{d}i + \int_0^1 \left(x_j^{FH}\right)^{1-\frac{1}{\sigma}} \mathrm{d}j \right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

is the composite consumption of manufacturing varieties from Home and Foreign. A^H is the consumption of clean goods. γE^G is the environmental damage function, measuring the disutility of global carbon emissions E^G.[3] γ is the marginal environmental damage. x_i^{HH} and x_j^{FH} represent the consumption of Home variety i and Foreign variety j, where the first uppercase letter in the superscripts denotes the location of production, and the second the location of consumption. μ is a coefficient. $\sigma > 1$ represents the constant elasticity of substitution between different varieties. The budget constraint of the representative individual in Home is

$$\int_0^1 p_i^{HH} x_i^{HH} \mathrm{d}i + \int_0^1 p_j^{FH} x_j^{FH} \mathrm{d}j + A^H = I^H. \tag{3}$$

p_i^{HH} and p_j^{FH} denote the prices of manufactured goods. I^H is total income. The corresponding variables for Foreign can be obtained symmetrically. We assume that μ, σ and γ are identical across countries. Because the firms and varieties are symmetric, we suppress the subscripts of i and j in the following analysis.

The production of manufactured goods incurs a marginal cost of c units of labor per unit and a fixed cost of FC units of labor. Without loss of generality, we normalize these production-related costs by setting $c = 0$ and $FC = 0$.[4] Each unit of manufactured goods generates one unit of emissions during production. And each unit of emissions requires one unit of emission permits for compliance. Firms purchase emission permits from domestic permit markets to cover their emissions. Permit markets are perfectly competitive, and all the permits are auctioned off to local firms. Permit prices are determined by the demand and supply of permits in the permit markets. We denote emission permits and permit prices by E^H and t^H in Home and E^F and t^F in Foreign. Global emissions are the sum of emissions from the two countries and given by $E^G = E^H + E^F$. Firms are environmentally conscious

[2] Considering trade costs of manufactured goods does not affect our results.

[3] The assumption of linear environmental damage function is common in the literature, e.g., Jinji (2013), Forslid et al. (2017) and Xing and Lee (2024). Considering convex environmental damage would make our model intractable because the markup pricing rule of the Dixit–Stiglitz monopolistic competition model does not apply in this case.

[4] Our results remain valid in the presence of positive marginal and fixed production costs.

and take corporate environmental responsibility (CER). When deciding on the production patterns, firms take into account global environmental damage which is defined as the sum of each country's environmental damage and equal to $2\gamma E^G$.

In country $S \in \{H, F\}$, firms' private profit functions (π) and objective functions with CER (V) are given by

$$\pi^S = p^{SH}x^{SH} + p^{SF}x^{SF} - t^S\left(x^{SH} + x^{SF}\right); \tag{4}$$

$$V^S = \pi^S - 2\beta^S\gamma E^G. \tag{5}$$

$\beta \geq 0$ measures the extent of firms' CER. $\beta = 0$ indicates usual profit-maximizing firms without environmental considerations, while a larger β signifies greater CER. We assume that firms in Home and Foreign may have different environmental consciousness. That is, β^H and β^F may differ.

Firms decide on the prices to maximize their objective functions with CER. The markup pricing rule of the Dixit–Stiglitz monopolistic competition model still applies in our analysis, yielding the prices of the dirty goods:

$$p^{HH} = p^{HF} = \frac{\sigma}{\sigma - 1}\underbrace{\left(t^H + 2\beta^H\gamma\right)}_{\equiv T^H}; \quad p^{FF} = p^{FH} = \frac{\sigma}{\sigma - 1}\underbrace{\left(t^F + 2\beta^F\gamma\right)}_{\equiv T^F}. \tag{6}$$

$t^H + 2\beta^H\gamma$ and $t^F + 2\beta^F\gamma$ are the internal carbon prices for the firms in Home and Foreign, denoted by T^H and T^F, respectively. With these prices, we can derive the aggregate price indices, P^H and P^F, and the consumption of each variety in Home and Foreign:

$$P^H = P^F = \frac{\sigma}{\sigma - 1}\left[\left(T^H\right)^{1-\sigma} + \left(T^F\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}; \tag{7}$$

$$x^{HH} = x^{HF} = \frac{\mu(\sigma - 1)}{\sigma}\frac{\left(T^H\right)^{-\sigma}}{\left(T^H\right)^{1-\sigma} + \left(T^F\right)^{1-\sigma}}; \tag{8}$$

$$x^{FF} = x^{FH} = \frac{\mu(\sigma - 1)}{\sigma}\frac{\left(T^F\right)^{-\sigma}}{\left(T^H\right)^{1-\sigma} + \left(T^F\right)^{1-\sigma}}. \tag{9}$$

Adopting CER increases the prices of dirty goods and decreases the consumption of them.

Firms' total demand for emission permits is $x^{HH} + x^{HF}$ in Home and $x^{FF} + x^{FH}$ in Foreign. Recall that the total supply of permits is E^H in Home and E^F in Foreign. Solving the market clearing conditions of emission permits gives the internal carbon prices in the two countries:

$$T^H = \frac{2\mu(\sigma - 1)}{\sigma}\frac{1}{E^H + \left(E^H\right)^{\frac{1}{\sigma}}\left(E^F\right)^{1-\frac{1}{\sigma}}}; \tag{10}$$

$$T^F = \frac{2\mu(\sigma - 1)}{\sigma}\frac{1}{E^F + \left(E^F\right)^{\frac{1}{\sigma}}\left(E^H\right)^{1-\frac{1}{\sigma}}}; \tag{11}$$

which are independent of firms' CER. Since the production and prices of dirty goods depend solely on the internal carbon prices, CER has no impact on them. Consequently, firms' sales profits, which are the sum of private profits and permit revenue, are also unaffected by CER:

$$p^{HH}x^{HH} + p^{HF}x^{HF} = \pi^H + t^H E^H = \frac{2\mu \left(T^H\right)^{1-\sigma}}{\left(T^H\right)^{1-\sigma} + \left(T^F\right)^{1-\sigma}}. \tag{12}$$

Permit prices are obtained as $t^H = T^H - 2\beta^H\gamma$ and $t^F = T^F - 2\beta^F\gamma$. An increase in β decreases the permit prices. Intuitively, as firms become more environmentally conscious, they produce less to generate fewer emissions. This in turn decreases the demand for emission permits, leading to lower permit prices. Therefore, given emission permits, firms have an incentive to adopt CER voluntarily to reduce permit prices and expenditures on permits, thereby increasing their private profits.

An increase in a country's emission permits decreases the permit prices and internal carbon prices in both countries:

$$\frac{\partial t^H}{\partial E^H} = \frac{\partial T^H}{\partial E^H} = -\frac{2\mu(\sigma-1)}{\sigma} \frac{1 + \frac{1}{\sigma}\left(E^H\right)^{\frac{1}{\sigma}-1}\left(E^F\right)^{1-\frac{1}{\sigma}}}{\left[E^H + \left(E^H\right)^{\frac{1}{\sigma}}\left(E^F\right)^{1-\frac{1}{\sigma}}\right]^2} < 0; \tag{13}$$

$$\frac{\partial t^F}{\partial E^H} = \frac{\partial T^F}{\partial E^H} = -\frac{2\mu(\sigma-1)}{\sigma} \frac{\left(1 - \frac{1}{\sigma}\right)\left(E^H\right)^{\frac{1}{\sigma}}\left(E^F\right)^{-\frac{1}{\sigma}}}{\left[E^H + \left(E^H\right)^{\frac{1}{\sigma}}\left(E^F\right)^{1-\frac{1}{\sigma}}\right]^2} < 0. \tag{14}$$

With these relationships, we can obtain that an increase in a country's emission permits decreases the prices of the dirty goods and increases the demand for the dirty goods produced there, i.e., $\partial p^{SH}/\partial E^S = \partial p^{SF}/\partial E^S < 0$, $\partial x^{SH}/\partial E^S = \partial x^{SF}/\partial E^S > 0$, $S \in \{H, F\}$.[5]

Home's welfare is represented by the indirect utility of the representative individual:

$$W^H = -\mu \ln P^H + I^H - \gamma(E^H + E^F) + \mu \ln \mu - \mu, \tag{15}$$

where $I^H = 1 + \pi^H + t^H E^H$. Here, "1" is the wage rate. $t^H E^H$ is the permit revenue distributed to the individual.

3 Emission permit competition

In this section, we investigate how Home and Foreign issue their emission permits non-cooperatively. Given Foreign's choices of permits, Home's best response is given by

$$\frac{\partial W^H}{\partial E^H} = -\mu \frac{\partial \ln P^H}{\partial E^H} + \frac{\partial \left(\pi^H + t^H E^H\right)}{\partial E^H} - \gamma = 0. \tag{16}$$

An increase in E^H decreases the aggregate price index in Home, which leads to higher consumer surplus:

$$-\mu \frac{\partial \ln P^H}{\partial E^H} = -\frac{\sigma}{2(\sigma-1)}\left(E^H \frac{\partial T^H}{\partial E^H} + E^F \frac{\partial T^F}{\partial E^H}\right) = \frac{\mu}{E^H + \left(E^H\right)^{\frac{1}{\sigma}}\left(E^F\right)^{1-\frac{1}{\sigma}}} > 0. \tag{17}$$

[5]See Appendix A for the proof.

On the other hand, a larger E^H decreases the prices of the dirty goods produced in Home but increases the demand for them. Since the latter effect dominates, firms' sales profits increase. This can be verified as follows:

$$\frac{\partial\left(\pi^H + t^H E^H\right)}{\partial E^H} = 2x^{HH}\frac{\partial p^{HH}}{\partial E^H} + 2p^{HH}\frac{\partial x^{HH}}{\partial E^H} = \frac{2\mu(\sigma-1)}{\sigma}\frac{\left(E^H\right)^{\frac{1}{\sigma}}\left(E^F\right)^{1-\frac{1}{\sigma}}}{\left[E^H + \left(E^H\right)^{\frac{1}{\sigma}}\left(E^F\right)^{1-\frac{1}{\sigma}}\right]^2} > 0. \tag{18}$$

Taking equations (17) and (18) into Home's best response function (16) yields

$$\frac{\mu}{E^H + \left(E^H\right)^{\frac{1}{\sigma}}\left(E^F\right)^{1-\frac{1}{\sigma}}}\left[1 + \frac{2(\sigma-1)}{\sigma}\frac{1}{1+\left(E^H\right)^{1-\frac{1}{\sigma}}\left(E^F\right)^{\frac{1}{\sigma}-1}}\right] = \gamma. \tag{19}$$

Analogously, we can derive Foreign's best response function:

$$\frac{\mu}{E^F + \left(E^F\right)^{\frac{1}{\sigma}}\left(E^H\right)^{1-\frac{1}{\sigma}}}\left[1 + \frac{2(\sigma-1)}{\sigma}\frac{1}{1+\left(E^F\right)^{1-\frac{1}{\sigma}}\left(E^H\right)^{\frac{1}{\sigma}-1}}\right] = \gamma. \tag{20}$$

Solving the two best response functions simultaneously yields countries' choices of emission permits at equilibrium:[6]

$$E^H = E^F = \frac{\mu(2\sigma-1)}{2\gamma\sigma}. \tag{21}$$

Internal carbon prices and permit prices at equilibrium in Home and Foreign are then derived as

$$T^S = \frac{2\gamma(\sigma-1)}{2\sigma-1}; \quad t^S = \frac{2\gamma(\sigma-1)}{2\sigma-1} - 2\beta^S\gamma; \quad S \in \{H, F\}. \tag{22}$$

We assume $\beta^S < (\sigma-1)/(2\sigma-1)$, so that the permit prices are always positive.

Proposition 1. *Under emission permit competition, each country's and global emission permits and emissions at equilibrium are independent of corporate environmental responsibility.*

At the non-cooperative equilibrium, firms' sales profits are equal to μ. Therefore, their private profits are expressed as

$$\pi^S = \mu - t^S E^S = \frac{\mu}{\sigma}\left[1 + (2\sigma-1)\beta^S\right]; \quad S \in \{H, F\}. \tag{23}$$

Given our assumption of $\sigma > 1$, it follows that $\partial\pi^S/\partial\beta^S = \mu(2\sigma-1)/\sigma > 0$. This implies that firms make more private profits as they are more environmentally conscious. Our findings suggest that CER may not necessarily reduce carbon emissions but can serve as a strategy for enhancing private profits.[7]

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[6] See Appendix A for detailed calculations.

[7] Similar to our findings, Xu and Lee (2023, 2024) show that firms may adopt CER to increase their profitability in the presence of green consumerism, as CER can increase consumers' willingness to pay for

4 Discussions

4.1 Emission tax competition

We first investigate how our results would change if Home and Foreign impose emission taxes rather than emission permits on carbon emissions. A key distinction between these two environmental policies lies in the determination of carbon price and emission level. Under emission permits, carbon price is determined endogenously by firms' demand for permits, while the level of emissions is capped by the supply of permits. By contrast, under emission taxes, carbon price is taken as given by firms, whereas the level of emissions is endogenously determined by firms' production. Due to this difference, countries' decisions on the stringency of environmental regulations are expected to be different as well. In Appendix B, we show that emission tax competition leads to more emissions, compared with emission permit competition. However, each country's and global emissions are still independent of firms' CER. Our findings in the main part continue to hold.

4.2 Asymmetric features

To keep our model simple and emphasize the role of CER, we assumed away other asymmetric features, such as differences in market sizes, emissions per unit of production, and environmental coefficients (γ). According to the literature (e.g., Forslid et al., 2017), a country tends to impose more stringent environmental regulations when it has a larger market size, lower emissions per unit of production, or greater environmental damage. Therefore, considering these asymmetric features would affect countries' choices of emission permits within the context of our analysis. However, the changes in countries' choices are not driven by firms' CER because the internal carbon prices at the permit market equilibrium do not depend on CER. Consequently, the equilibrium permits and emissions remain independent of CER.[8]

4.3 Abatement activities

For simplicity, we did not incorporate abatement in our analysis. The impact of such activities on our results depends on the specific types of abatement considered. In the literature, Bárcena-Ruiz and Sagasta (2022) incorporate end-of-pipe abatement with convex abatement cost; Jinji (2013) models reductions in emissions per unit of production and convex abatement cost per unit of production; and Forslid et al. (2017) and Cheng (2024) treat emissions as an input that decreases with more labor. Including these types of abatements would render our model intractable, as deriving explicit permit prices would be unfeasible. Our results would be modified if the effects of permits on internal carbon prices were dependent on CER. An alternative form of abatement is the adoption of green technologies by firms. Specifically, firms may choose greener technologies for production by incurring marginal and fixed costs, thereby reducing emissions per unit of production and potentially lowering total emissions. In this scenario, the analysis would parallel that of asymmetric emissions per unit

green products.

[8]See Appendix C for details.

of production between the two countries. By conjecture, our primary results would remain valid. A detailed analysis of abatement activities is left for future research.

5 Conclusion

We employed a monopolistic competition model to investigate how CER affects countries' choices of emission permits and their emissions. We found that higher CER decreases carbon prices but does not affect environmental outcomes. However, firms' private profits become higher because of higher CER. Our findings suggest that relying solely on voluntary CER initiatives is insufficient to achieve meaningful environmental improvements. Instead, governments should implement binding regulatory measures, such as mandatory environmental quality standards, to ensure that firms' environmental efforts translate into real and measurable emission reductions. Importantly, the potential for regulatory capture poses a challenge, as firms may lobby against the implementation of mandatory CER policies. We leave these political economy issues for future research.

A final remark is in order to conclude the paper. Throughout the main analysis, we have treated the extent of CER, represented by β^H and β^F, as exogenously given, abstracting from firms' strategic choices regarding CER intensity. Intuitively, if CER were endogenously determined, firms would have an incentive to adopt higher levels of CER, as doing so increases their private profits. However, this conclusion may not hold in the presence of free entry. Higher profits associated with greater CER would attract new entrants, potentially offsetting the gains from CER and altering firms' strategic behavior. Moreover, when governments set emission permit levels, they must account for the impact on market entry, which may in turn influence the equilibrium level of CER. A detailed analysis of the joint determination of CER and firm entry goes beyond the scope of this paper and is left for future research.

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