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Hiroaki Yamagami - Ryo Arawatari -
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Ambitious Emissions Goal as a Strategic Preemption*

Hiroaki Yamagami,† Ryo Arawatari,‡ and Takeo Hori§

Abstract

We model a political game where a policymaker pledges a domestic emissions goal in the context of instrument choice between carbon pricing (CP) and a quota approach. We show that, although the policymaker faces an emissions goal proposed from an international environmental agreement, she may pledge a more stringent emissions than the proposed level. We define this stringent goal as an "ambitious emissions goal". We show that the ambitious emissions goal acts as a strategy for the policymaker that preempts the industry's lobby in a subsequent stage. We also suppose that, if CP is introduced, a rent-seeking contest for the CP revenue refund is held. Then, if the contest is socially costly enough, CP is no longer an optimal instrument. Finally, we extend the model of one country to that of two symmetric countries. A Nash equilibrium where both countries pledge the ambitious emissions goals remains.

Keywords: Lobby; Carbon pricing; Quota; Revenue refund; Rent-seeking

JEL classification: D72; Q58

1 Introduction

"... Ambition must guide all Member States as they prepare their nationally determined contributions for 2020 to reverse the present trend in which climate change is still running faster than us. It is our duty to reach for more and I count on all of you to raise ambitions so that we can beat back climate change." UN Secretary-General António Guterres, December 15, 2018, from remarks at the conclusion of the COP24 at Katowice, Poland.[1]

The Paris agreement (Article 2) suggests two targets: (1) keeping the global temperature rise in this century well below 2 degrees Celsius and (2) pursuing efforts to limit the temperature increase

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†Faculty of Economics, Seikei University. Address: 3-3-1, Kichijoji-kitamachi, Musashino-shi, Tokyo 180-8633, Japan. E-mail: yamagami@econ.seikei.ac.jp.

‡Faculty of Economics, Doshisha University. Address: Karasuma-higashi-iru, Imadegawa-dori, Kamigyo-ku, Kyoto-shi 602-8580, Japan. E-mail: rarawatari@mail.doshisha.ac.jp

§Department of Social Engineering, Tokyo Institute of Technology. Address: 2-12-1, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan. E-mail: hori.t.ag@m.titech.ac.jp.

[1] All remarks can be found in https://www.un.org/press/en/2018/sgsm19409.doc.htm

even further, to 1.5 degrees Celsius.[2] The Paris agreement (Article 4) allows the contracting parties to set their own emissions goals (NDCs: Nationally Determined Contributions). Then, the double-standard goals may incentivize the contracting parties to aim at the easier goal (1). Against this conjecture, ambitious groups of countries and cities, such as the High Ambition Coalition, C40 Cities and CNCA (Carbon Neutral Cities Alliance) have appeared. These groups pledge reducing net carbon emissions by 80–100% by 2050 to limit the temperature increase to 1.5 degrees Celsius.

Why are they so ambitious? The emissions abatement is costly but constitutes a public good. Policymakers may have an incentive to free ride on others' contributions. In answering the aforementioned question, a primary reason must be attributed to the altruism or benevolence of the policymakers. Additionally, our study presents another strategical reason for the ambition by focusing on domestic political processes of environmental policy design. Pechar et al. (2018) examine a relationship between policy design and ambition from a perspective of environmental politics. Our paper supports their assertion, from an economic perspective, that the ambitious countries in emissions reductions tend to have carbon pricing policies rather than quantity regulation policies.

We consider the political processes of an instrument choice either carbon pricing (CP) or a quota approach (Quota). This is a basic issue of the environmental policy design, which has been examined in many previous papers. A common agency model or the electoral model of Grossman and Helpman (1994, 1996) are often used to examine the lobbying (e.g., Fredriksson, 1997; Aidt, 1998 and 2010; Fredriksson and Sterner, 2005; Sterner and Isaksson, 2006; and Miyamoto, 2014). These models assume that policymakers are agents setting rents, and lobbyists (or voters) act as principals seeking rents (cf. Epstein and Nitzan, 2007). Keeping this principal-agent relation, we simplify the industry's lobbying as a discrete choice: paying a given amount or not.

We also allow for a citizens' campaign in a redistribution conflict regarding CP revenue. "Citizens Climate Lobby (CCL)" is one of the citizen groups in the United States that promotes CP. More importantly, CCL advocates a full transfer of CP revenue to households at the same time. Furthermore, 3,419 US economists published a statement on carbon dividends in the Wall Street Journal on January 17, 2019. Their statements propose introducing both CP and a basic income for US citizens. More than 1,500 economists also revealed the same statement via European

[2] IPCC (2018) provides a estimation of global GHG (Greenhouse effect gases) emissions reduction compared to 2010. Target (1) corresponds to 25% decrease by 2030 and 100% decrease by 2070, and Target (2) to 45% decrease and 100% decrease by 2050.

Association for Environmental and Resource Economists in July 2019. These actors advocate this policy package because the manner of refunding the revenue from environmental taxes that have been introduced varies by country.[3] For example, in Italy, the environmental tax revenue is refunded by cutting employment charges and, in the United Kingdom, through contributions to national insurance. In the United Kingdom and Japan, there are also subsidies on clean production technology development financed by the emissions tax revenue. These refunding manners benefit the industry. On the other hand, in Sweden and Australia, the revenue is mainly distributed to households. Sweden cuts personal income taxes, and Australia not only cuts income taxes but also increases pensions, allowances, and family payments. There are countries where both firms and households benefit from the revenue, as in British Columbia in Canada, and in Denmark, Finland, Germany, the Netherlands, and Norway. [4]

We set a five-stage political game of environmental policy design with one citizen, one industry, and one policymaker. At stage 1, the policymaker pledges the domestic emissions goal at stage 1 to minimize the social cost. At the same time, she faces an amount of emissions proposed to be achieved in an international environmental agreement (IEA). Subsequently, one instrument either carbon pricing (CP) or a quota approach (Quota) is chosen through costless citizen's vote at stage 2. In contrast, at stage 3, the industry can alter its choice through costly lobbying. The instrument choice affects the industry's profit and the citizen's welfare. CP imposes on the industry both emissions abatement costs and payments for emitting carbon. Quota increases the polluters' costs only through abatement costs. The citizen receives a transfer based on the revenue raised by CP but nothing when Quota is introduced. Consequently, the citizen votes for CP, whereas the industry has an incentive to lobby for Quota.[5] However, since lobbying is costly, we show conditions under which the industry lobbies. If CP is consequently introduced, a rent-seeking contest is held at stage 4, through which the share of revenue refund between the industry and the citizen is decided. Both the industry and the citizen spend an amount of money in the contest to obtain a larger revenue refund. Finally, the industry decides its emissions level at stage 5.

[3]See, for detail, Withana et al. (2013) and the OECD database (http://www2.oecd.org/ecoinst/queries/).

[4]The revenue refund must have indirect effects. A transfer to the industry does not only benefit the firms directly but also the households indirectly, by stimulating employment. In contrast, our study assumes that the political actors only aim for their own direct benefits.

[5]We suppose the industry lobby as a lump-sum spending of a given constant cost. By spending this exogenous amount, the industry can change the instrument initially chosen by the policymaker to the other. This lobbying can be interpreted as that conducted by a commercial lobbying industry. Groll and Ellis (2014) consider a lobbying market that determines the unit price of lobbying at equilibrium. Our study is a partial equilibrium analysis, focusing only on the emissions abatement sector, while assuming a given lobbying service price.

With this model, we show that an ambitious emissions goal can be induced through the industry's lobby on instrument choice. We define the ambitious emissions goal as an emissions level strictly smaller than a proposed emissions goal in the IEA. We find that when the industry's lobbying cost on instrument choice is small enough, the policymaker pledges the ambitious emissions goal for a certain range of the proposed goals. The ambitious emissions goal preempts the socially costly lobby on instrument choice by reducing the benefits from lobbying.

Our model supports many previous papers for most cases that CP is socially preferred to Quota. However, if a rent-seeking contest of revenue refund from CP is more costly than the industry's lobby on instrument choice, Quota becomes a socially preferred instrument. Then, even if Quota is socially preferred, the citizen votes for CP in stage 2 as far as the revenues from CP are transferred to the citizen. This citizen's choice is considered a failure on the part of the democracy. On the other hand, we find that the industry's lobby on instrument choice corrects this choice in a subsequent stage.

Some studies investigate the redistribution related to environmental policy through the rent-seeking contest of Tullock (1980). Dijikstra (1998) examines the timing of the instrument choice and the endogenous revenue division in a two-stage rent-seeking contest between two agents. McKenzie and Ohndolf (2012) show that a non-revenue-raising policy is socially preferred to a revenue-raising policy in most cases because of wasteful lobbying investments for obtaining the revenue return. Our model supports the outcome of McKenzie and Ohndolf (2012) when the lobbying cost is small enough and the emissions goals are at a medium level. Moreover, although the emissions target is fixed in Dijikstra (1998) and McKenzie and Ohndolf (2012), our study clearly distinguishes between the proposed goal in an IEA and the domestic national emissions goal. This difference in international and national levels of emissions goals yields a strategic preemption of the lobbying when ambitious emissions targets are set. McKenzie (2017) shows that the distributional rent-seeking behavior affects the instrument choice under uncertainty regarding the emissions abatement cost. This study, however, supposes that the households are not politically active.

To discuss further, we extend the domestic game to that with two symmetric countries. A sum of their pledging goals must satisfy a given global goal. In this model, although each country can free ride on the other country's contribution, we find a Nash equilibrium where both countries pledge the ambitious emissions goals.

2 Model

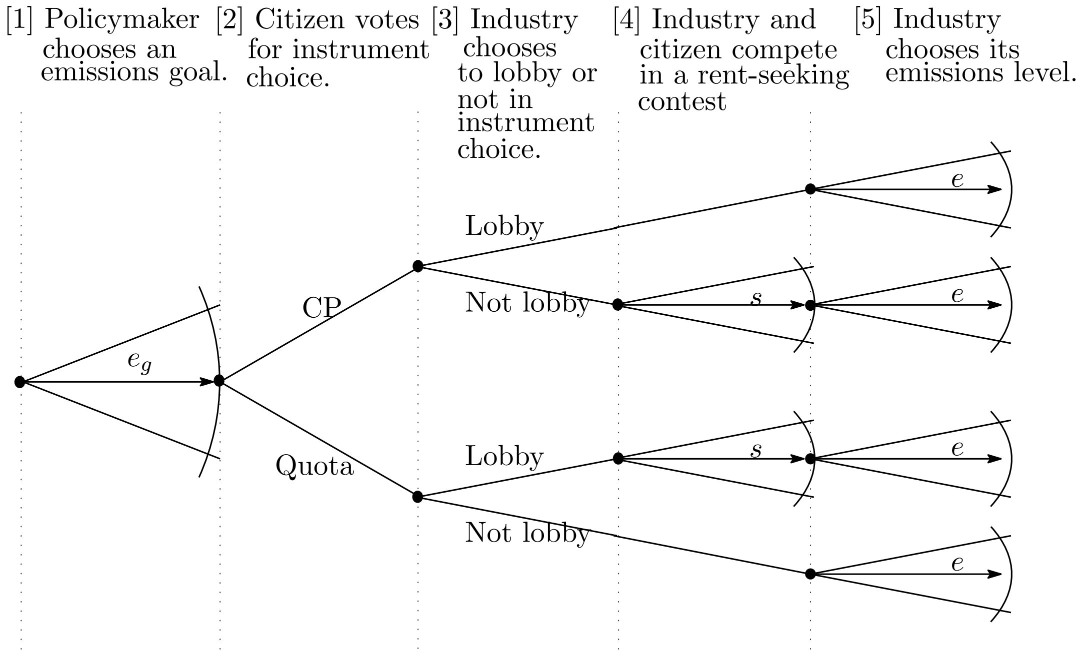

Figure 1: Timings of Decision-making

We model a one-country five-stage game of instrument choice with one citizen, one industry, and one policymaker.[6] The policymaker faces an emissions target, e_{int}, given in an international environmental agreement (IEA, hereafter).[7] At first stage, the policymaker pledges the domestic emissions goal of its own country, e_g, which does not violate the proposed emissions goal in the IEA, $e_g \leq e_{int}$. Secondly, according to the voting result of the citizen, the policymaker initially chooses one instrument, either carbon pricing (CP, hereafter) or a quota approach (Quota, hereafter), to achieve the domestic goal. At third stage, depending on the industry's lobby on the instrument choice, the policymaker reconsiders the instrument choice. If the instrument initially chosen at the second stage is not the one preferred by the industry, the industry can change the decision by spending a required amount on lobbying, R. Moreover, if CP is chosen and introduced, a contest is held as fourth stage, where the industry and the citizen spend money on

[6]See Section 4 for discussions on a two-country Nash game of domestic emissions goal.

[7]e_{int} can be interpreted as the emissions level proposed to maintain the global average temperature increase well below 2 degrees Celsius above pre-industrial levels. According to IPCC (2018), this goal corresponds to, with at least 66% of probability, a decline of CO_2 emissions by about 25% from 2010 levels by 2030 and net zero emissions by around 2070. Moreover, Paris agreement ideally aims at limiting global warming to 1.5 degrees by 2100. This goal corresponds to global CO_2 emissions decline by about 45% from 2010 by 2030, reaching net zero around 2050 according to IPCC (2018). Although we regard e_{int} as the emissions pathway limiting global warming to below 2 degrees Celsius, we show cases where the country pledges ambitious goals that are strictly smaller emissions than e_{int} such as the emissions goal for limiting global warming to 1.5 degrees Celsius.

a campaign to obtain the return from the CP public revenue. Finally, at fifth stage, the industry chooses its emissions level, e, under either Quota or CP. The timeline for the decision is described in Figure 1. We study this game through backward induction.

2.1 Fifth Stage: Emissions

Quota is a free allocation of the emission units, e_Q, to the industry. The industry then bears only costs for cutting emissions. The industry chooses its emissions level, e, so that it is less than e_Q: $e \leq e_Q$. The industry minimizes the cost related to its emission: $c_Q(e) = \frac{c}{2}(\bar{e} - e)^2$, s.t. $e \leq e_Q$ and $e_Q \leq \bar{e}$. c is a parameter for marginal abatement cost. $\bar{e}$ is the maximum amount of emissions when the industry does not make any effort in reducing emissions. The industry then sets its emissions to the ceiling level, that is, $e^* = e_Q$. The domestic emissions goal is achieved by setting emissions ceiling to this level, $e_Q = e_g$. The minimized cost under Quota is then written as

$$c_Q(e_g) = \frac{c}{2}(\bar{e} - e_g)^2. \tag{1}$$

CP imposes a unit tax rate, t, on emissions. The industry has to pay on every unit of emission, and thus trades offs between cutting emissions and paying the tax. The industry chooses its emissions to minimize the cost $c_P = \frac{c}{2}(\bar{e} - e)^2 + te - G$, where G is a lump-sum transfer from the government to the industry. By taking G as given, the industry sets its emissions levels to $e_P^* = \bar{e} - t/c$. The policymaker can achieve the emissions goal, e_g, by setting the emissions tax to the targeted rate $t = c(\bar{e} - e_g) \equiv t_g$. G is financed by revenues from the emissions tax, with $G = s \cdot t_g e_g$, where $s \in [0, 1]$ is the refund rate of tax revenue to the industry. The rest is transferred to the citizen. When t_g is introduced, the minimized cost can be written as

$$c_P(e_g, s) = \frac{c}{2}(\bar{e} - e_g)^2 + (1 - s)c(\bar{e} - e_g)e_g. \tag{2}$$

The first term in (2) is the cost for emissions reduction, which is the same as that in (1). The second term is a net tax payment: the difference between the total tax payment and the transfer from the government. From (1) and (2), the industry strictly prefers Quota to CP as long as $0 \leq s < 1$, because of the positive net tax payment.

The citizen suffers from pollution emissions and receives a transfer from the government, if any. Because the two instruments under a given emissions target consequently produce identical environmental damage, we omit the damage from the citizen's payoff. Then, the citizen's benefit each policy can be written as:

$$[\text{Quota}] \qquad b_Q = 0; \tag{3}$$

$$[\text{CP}] \qquad b_P(e_g, s) = (1-s)c(\bar{e} - e_g)e_g. \tag{4}$$

If we ignore the environmental damage, the citizen earns nothing under Quota, whereas, under CP, he or she receives the transferred revenue. Therefore, the citizen strictly prefers CP to Quota, as long as $0 \leq s < 1$.[8]

2.2 Fourth Stage: Rent-seeking Contest

The industry and the citizen spend political contributions, d_I and d_C, in the contest to obtain a higher revenue return from CP. The return rate of the revenue from CP to the industry is determined as a share of the total amount spent by the two parties (cf. Dijkstra, 1998; McKenzie and Ohndolf, 2012; McKenzie, 2017): $s(d_I, d_C) = \frac{d_I}{d_I + d_C}$.[9]

The industry faces the following updated cost: $C_P(e_g, d_I, d_C) = c_P(e_g, s(d_I, d_C)) + d_I = \frac{c}{2}(\bar{e} - e_g)^2 + \frac{d_C}{d_I + d_C} c(\bar{e} - e_g)e_g + d_I$. The citizen receives the updated benefit: $B_P(e_g, d_I, d_C) = b_P(e_g, s(d_I, d_C)) + d_C = \frac{d_C}{d_I + d_C} c(\bar{e} - e_g) + d_C$.

The non-trivial Nash equilibrium level of spending by each agent in the contest is derived as $d_I^* = d_C^* = \frac{c(\bar{e} - e_g)e_g}{4}$. The numerator is the tax revenue. In other words, the tax revenue makes the contest competitive by inducing each agent to spend. As a result, each agent in the contest spends one quarter of the tax revenue. The refund rate, the costs for the industry, and the benefit for the citizen are

$$s^* = 1/2, \qquad C_P(e_g) = \frac{c}{2}(\bar{e} - e_g)^2 + \frac{3}{4}c(\bar{e} - e_g)e_g, \qquad B_P(e_g) = \frac{1}{4}c(\bar{e} - e_g)e_g. \tag{5}$$

The refund rate is the same for both agents. Although half of the revenue is transferred to each agent, the realized payoffs are reduced by the money spent in the contest. The expenditure

[8] We can consider a case where the industry does not consider G as given. In this case, we obtain $e_P^* = \bar{e} - t(1-s)/c$ which is greater than that in case where G is given for the industry. This setting implies that achieving e_g requires higher tax rates: $t_g = c(\bar{e} - e_g)/(1-s)$. The cost and benefit functions of the industry and the citizen are then given as $c_P(e_g) = (c/2)(\bar{e} - e_g)^2 + c(\bar{e} - e_g)e_g$ and $b_P(e_g) = c(\bar{e} - e_g)$, instead of (2) and (4). Since the cost and benefit functions are independent of the share of the revenue refund, s, both the industry and the citizen do not pay contributions in a rent-seeking contest as shown at Stage 4. This results in $s = 1/2$ which does not qualitatively influence the result of the model.

[9] We can consider uneven political influences on the tax refund rate, s, between the industry and the citizen such as $s = \alpha d_I/(\alpha d_I + d_C)$ with $\alpha > 0$. This may correspond to weights in social welfare for the policymaker as in the electoral competition model of Grossman and Helpman (1996). With this setting, we reach to $s = 1/2$ as well as (5) and therefore the qualitative results are not changed. Therefore, we assume that the political influences on s from the industry and the citizen are equivalent between the industry and the citizen to avoid complexity.

implies the net cost of the contest.

2.3 Third Stage: Industry's Lobbying in Instrument Choice

In the third stage, we examine the industry's lobbying on the instrument choice. From (1) and (5), the cost gap for the industry between CP and Quota is $\Delta C(e_g) = C_P(e_g) - c_Q(e_g) = \frac{3}{4}c(\bar{e}-e_g)e_g > 0$. Since Quota imposes smaller costs on the industry for any e_g, the industry prefers Quota. Likewise, from (3) and (5), the benefit gap for the citizen is $\Delta B(e_g) = B_P(e_g) - b_Q(e_g) = B_P(e_g) > 0$. Since CP benefits the citizen more than Quota for any e_g, the citizen prefers CP. Lemma 1 provides the industry and the citizen's preferences between the two instruments.

Lemma 1 *The industry prefers Quota, whereas the citizen prefers CP.*

Since the industry prefers Quota from Lemma 1, the industry does not lobby when Quota is chosen first. Therefore, at this stage, we consider only the case where CP is first chosen in the second stage.[10] The industry then has an incentive to lobby and change the instrument choice. The policymaker changes his or her choice if the industry spends an exogenous amount, $R > 0$, on lobbying activities.[11] The industry lobbies if and only if $\Delta C(e_g) < R$.[12] $\Delta C(e_g)$ exhibits an inverted-U curve, with $\Delta C(0) = \Delta C(\bar{e}) = 0$. The trajectory corresponds to the net tax payment as in a Laffer curve but reduced by the amount spent in the contest and that transferred to the citizen.

Let $\bar{R}$ be the maximized amount of the net tax payment $\Delta C(e_g)$:

$$\bar{R} = \Delta C\left(\frac{\bar{e}}{2}\right) = \frac{3c\bar{e}^2}{16}. \tag{6}$$

When $R < \bar{R}$, there exist two emissions goals, $e_g = e_1,\ e_2$, satisfying $\Delta C(e_g) = R$, given by

$$e_1 = \frac{\bar{e}}{2} - \sqrt{\frac{\bar{e}^2}{4} - \frac{4R}{3c}}, \qquad e_2 = \frac{\bar{e}}{2} + \sqrt{\frac{\bar{e}^2}{4} - \frac{4R}{3c}}. \tag{7}$$

The discussion so far results in Lemma 2.[13]

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[10] As shown below in this subsection, the policymaker consequently chooses CP in the second stage.

[11] We assume that the lobbying cost, R, is given from an external lobbying market as in Groll and Ellis (2014), which determines a unit price of lobbying services in its equilibrium. The industry is assumed to choose to lobby or not as a discrete choice.

[12] Without loss of generality, we assume that the industry does not lobby when $\Delta C(e_g) = R$.

[13] If the rent-seeking contest is not held, s is exogenously given. For the industry, the cost gap between Quota and CP is then given by the difference of (1) and (2): $\Delta c(e_g, s) = c_P(e_g, s) - c_Q(e_g) = (1-s)c(\bar{e}-e_g) - e_g$. We can easily show that the refund share to the industry which preempts the lobbying on the instrument choice (s_{pr}) by manipulating $\Delta c(e_g, s_{pr}) \leq R$ as $s_{pr} \geq 1 - \frac{Re_g}{c}(\bar{e}-e_g)$. s_{pr} is less than 1 for any $R \geq 0$ and $e_g \in [0, \bar{e}]$. As the refund share is endogenized in the rent-seeking contest, the policymaker has to consider another way to preempt

Lemma 2 *Suppose that the policymaker initially chooses CP. This instrument choice is changed to Quota through the industry's lobbying when* $R < \bar{R}$ *and* $e_g \in (e_1, e_2)$*. Otherwise, CP remains.*

2.4 Second Stage: Citizen's Voting in Instrument Choice

At this stage, the citizen also takes a political action in instrument choice through voting. The policymaker chooses an instrument subject to the citizen's voting behavior. The citizen is given the right to vote for the instrument choice without any cost. Since the citizen prefers CP from Lemma 1 and votes for it with no cost. The policymaker thus initially chooses CP at this stage. If Quota is subsequently introduced, this is a result of the industry's lobby of the third stage. The industry's cost under Quota is thus rewritten as

$$C_Q(e_g, R) = c_Q(e_g) + R = \frac{c}{2}(\bar{e} - e_g)^2 + R. \tag{8}$$

2.5 First Stage: Domestic Emissions Goal

We assume that an emissions goal proposed in an IEA, e_{int}, is given as an emissions ceiling distributed to the country in question.[14] The policymaker has to achieve $e \leq e_{int}$. For this purpose, he or she pledges a domestic emissions goal, e_g, which satisfies $e_g \leq e_{int}$ and minimizes the social cost.[15] From (1), (2), (3), (5), (8) and Lemma 2, the social costs when Quota and CP are introduced are given as follows

$$\text{[Quota]} \quad SC_Q(e_g, R) = C_Q(e_g, R) - b_Q(e_g) = \frac{c}{2}(\bar{e} - e_g)^2 + R \quad \text{if } R < \bar{R} \text{ and } e_g \in (e_1, e_2); \tag{9}$$

$$\text{[CP]} \quad SC_P(e_g) = C_P(e_g) - B_P(e_g) = \frac{c\bar{e}}{2}(\bar{e} - e_g) \quad \text{otherwise.} \tag{10}$$

When $R \geq \bar{R}$, CP is introduced for all emissions targets because the lobbying cost is too expensive. For given e_{int}, the policymaker sets $e_g = e_{int}$ as depicted in Figure 2 (a). The realized social cost follows a trajectory of that under CP for all e_{int}, which is shown in Figure 2(a').

According to Lemma 2, when $R < \bar{R}$, the industry lobbies to change the instrument choice

the lobbying if necessary.

[14] e_{int} is not necessarily the optimally distributed emissions goal to each country in an IEA. For example, Paris agreement suggests two levels of emissions goal such as global warming of 1.5 and 2 degrees Celsius in 2100 compared to pre-industrial levels. This fact implies that whereas the optimal emissions level is still uncertain, the contracting countries share the common goals at least to avoid expected catastrophic situations. Our model also considers such situation.

[15] In reality, the instrument choice requires legislative processes and cannot ignore the citizens' voice. However, the emissions goal tends to be determined only by the cabinet committee or limited experts and can be declared to the public without consensus. Therefore, we assume that, in the first stage, the policymaker sets the emissions goal to minimize the social costs but, in the second stage, chooses the instrument by taking into account the citizen's benefit.

for $e_g \in (e_1, e_2)$. Once the industry lobbies, the lobbying cost increases the social cost. Then, there exists a range of the lobbying cost, R, that satisfies $R < \bar{R}$ and $SC_Q(e_2, R) \geq SC_P(e_1)$. Letting R' be the lobbying cost that satisfies $SC_P(e_1) = SC_Q(e_2, R')$, we derive it by using (7), (9) and (10):

$$R' = c\bar{e}^2 \left(-6 + \sqrt{38 + \frac{1}{4}} \right) \approx 0.185\, c\bar{e}^2 > 0. \tag{11}$$

When $R' < R < \bar{R}$, the social costs under Quota for $e_g \in (e_1, e_2)$ are greater than those under CP for $e_g = e_1$.

Let us call a domestic emissions goal that is strictly more stringent than the proposed emissions goal in an IEA as an "ambitious emissions goal," that is, $e_g < e_{int}$. Subject to $e_g \leq e_{int}$, the policymaker can decrease the social costs for $e_{int} \in (e_1, e_2]$ by strategically pledging the ambitious emissions goal instead of $e_g = e_{int}$. The ambitious emissions goal then diminishes the cost gap to the industry between CP and Quota as $C_P(e_1) = c_Q(e_1) + R$, and therefore preempts the lobby. The set of domestic emissions goals with respect to e_{int} is described in Figure 2(b). Consequently, CP is introduced for any $e_{int} \in [0, \bar{e}]$, and the social cost curve becomes discontinuous at $e_g = e_1, e_2$ as depicted in Figure 2(b').

When the lobbying cost is further smaller such as $R < R'$, there is a range in e_{int} where the ambitious emissions goal cannot reduce the social cost for $e_{int} \in (e_1, e_2)$. Let e_3 be an proposed emissions goal in the IEA that satisfies $SC_P(e_1) = SC_Q(e_3, R)$ when $R < R'$. We derive it with (7), (9) and (10):

$$e_3 = \bar{e} - \sqrt{\frac{\bar{e}^2}{2} - \frac{2R}{c} + \bar{e}\sqrt{\frac{\bar{e}^2}{4} - \frac{4R}{3c}}}. \tag{12}$$

When $R < R'$, the social costs under Quota for $e_{int} \in (e_1, e_3)$ are greater than those under CP for $e_g = e_1$. The ambitious emissions goal then preempts the lobby and results in smaller social cost for $e_{int} \in (e_1, e_3]$. In contrast, the social cost when the ambitious goal is pledged is greater than those for $e_{int} \in (e_3, e_2)$ under Quota. The policymaker thus pledges the ambitious goal only for $e_{int} \in (e_1, e_3]$, whereas Quota is introduced via lobbying. Figure 2 (c) depicts a strategy set of domestic emissions goal. As a result, the social cost curve is discontinuous at $e_{int} = e_1, e_3, e_2$, as shown in Figure 2(c').

The discussion so far yields a plan for domestic emissions goals based on the proposed goals

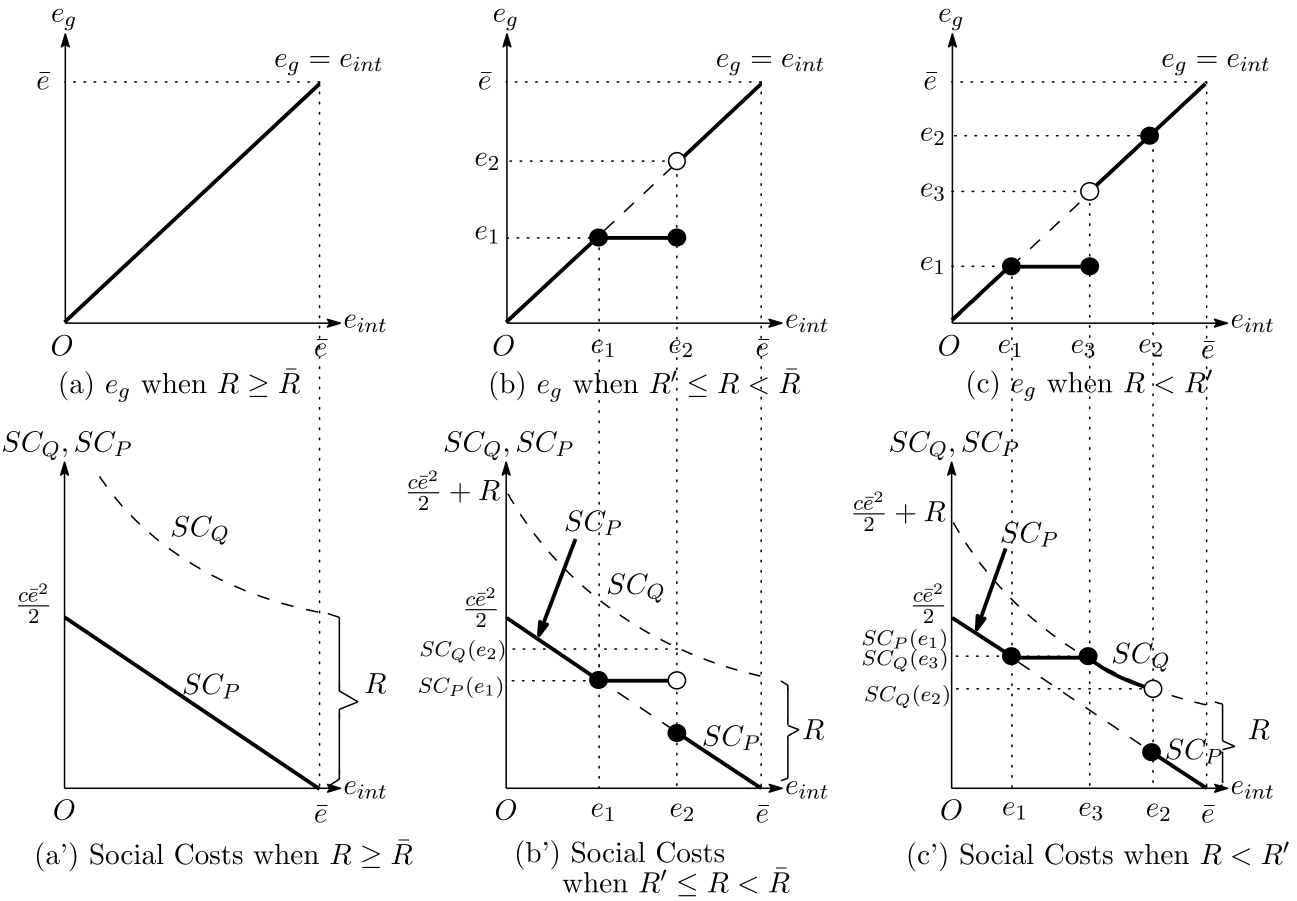

Figure 2: Emissions goal strategy set and social costs curve when $R < \bar{R}$

in the IEA and Proposition 1.

$$e_g = f(e_{int}) = \begin{cases} e_{int} & \text{for } e_{int} \in [0, \bar{e}] \quad \text{if } R \geq \bar{R}, \\ \left.\begin{array}{ll} e_{int} & \text{for } e_{int} \in [0, e_1] \\ e_1 < e_{int} & \text{for } e_{int} \in (e_1, e_2] \\ e_{int} & \text{for } e_{int} \in (e_2, \bar{e}] \end{array}\right\} & \text{if } R' \leq R < \bar{R}, \\ \left.\begin{array}{ll} e_{int} & \text{for } e_{int} \in [0, e_1] \\ e_1 < e_{int} & \text{for } e_{int} \in (e_1, e_3] \\ e_{int} & \text{for } e_{int} \in (e_3, \bar{e}] \end{array}\right\} & \text{if } R < R'. \end{cases} \tag{13}$$

Proposition 1 *The ambitious emissions goal $e_g = e_1 < e_{int}$ preempts the industry's lobbying and lowers the social costs for $e_{int} \in (e_1, e_2]$ if $R' \leq R < \bar{R}$, and for $e_{int} \in (e_1, e_3]$ if $R < R'$.*

Proposition 1 thus shows that the ambitious emissions goal can be induced via a lobby in instrument choice other than an altruism or a benevolence.

2.6 Optimal Instrument and Lobby

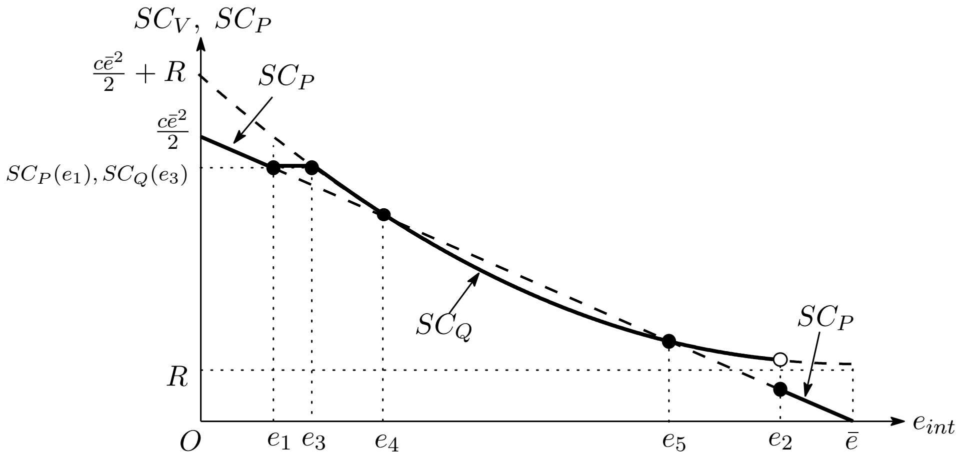

Figure 3: Social cost curve when $R < \frac{c\bar{e}^2}{8} < R'$

We examine which instrument leads to smaller social costs, given the lobbying cost for instrument choice and the proposed emissions goal in the IEA. For this purpose, we rearrange $SC_Q(e_g, R) < SC_P(e_g)$ with (9) and (10) as $R < \frac{c\bar{e}^2}{8}$. Since $R' > \frac{c\bar{e}^2}{8}$ from (11), there exists e_3 as well as Figure 2(c') and the policymaker preempts the lobby for $e_{int} \in (e_1, e_3]$ with the ambitious emissions goals, $e_g = e_1$. Figure 3 illustrates this case.

Then, there exist two emissions levels, $e_{int} = e_4,\ e_5$, which satisfy $SC_Q(e_{int}, R) = SC_P(e_{int})$:

$$e_4 = \frac{\bar{e}}{2} - \sqrt{\frac{\bar{e}^2}{4} - \frac{2R}{c}}, \qquad e_5 = \frac{\bar{e}}{2} + \sqrt{\frac{\bar{e}^2}{4} - \frac{2R}{c}}. \tag{14}$$

Quota is strictly socially preferred to CP for $e_{int} \in (e_4, e_5)$. A gap in social costs between CP and Quota is given by $SC_Q(e_g, R) - SC_P(e_g) = R - \frac{c}{2}(\bar{e} - e_g)e_g$. Note that the second term is the total contributions in the rent-seeking contest, that is, $d_I^* + d_C^* = \frac{c}{2}(\bar{e} - e_g)e_g$. Therefore, Quota is socially preferred because the total contributions in the rent-seeking contest is more costly than the lobby. Additionally, the amount spent on the contest increases in the tax revenue, $t_g \cdot e_g = c(\bar{e} - e_g)e_g$. The range on e_{int} where Quota is socially preferred appears at approximately the middle of $e_g \in [0, \bar{e}]$, which corresponds to the range resulting in the maximal value of the Laffer curve.

Remind the second stage where the citizen votes for CP. Even if Quota is socially preferred, the policymaker initially chooses CP through the citizen's voting result. This democratic choice makes a government's failure for $e_{int} \in (e_4, e_5)$. However, since the lobbying cost is small enough, this failure can be corrected. From the discussion so far, we obtain Proposition 2.

Proposition 2 *If the rent-seeking contest is more costly than the industry's lobby, the latter improves welfare by correcting the government's failure in the instrument choice.*

3 Extension to a Two-country Game

We can extend the domestic model in the previous section to a Cournot-Nash game with two symmetric countries in pledging their emissions goals. Referring to these two identical countries as country A and B, we define e_{gA} and e_{gB} as domestic emission goals in each country. Let E be the world total emission goal such as the international emission goal under Paris agreement. Then, the world goal satisfies $E = e_{gA} + e_{gB}$. Furthermore, we put subscripts A, B to all domestic variables to distinguish the countries. Therefore, when the two countries do not make any effort to reduce emissions, the total amount of emissions becomes $\bar{E} = \bar{e}_A + \bar{e}_B = 2\bar{e_A} = 2\bar{e}_B$. For this section, we assume only one case shown below.

Assumption 1 *The two symmetric countries aim at achieving a half amount of $\bar{E}$ under an international environmental agreement, that is, $E = \bar{E}/2$.*

This assumption implies $E = \bar{e}_A = \bar{e}_B$. Given the world emissions goal, E, the policymaker in each country pledges its emissions goal in response to the emissions goal of the other country. The emissions goals of the two countries then satisfy $E = e_{gA} + E - e_{gB}$ with $e_{gA}, e_{gB} \geq 0$.

We then consider emissions goal of country A. The policymaker in country A minimizes its own country's social cost, (9) and (10), by taking E and e_{gB} as given. The two symmetric countries face same lobbying cost $R = R_A = R_B$. By substituting $e_{int} = E - e_{gB}$ into (13), the reaction functions for country A are given as

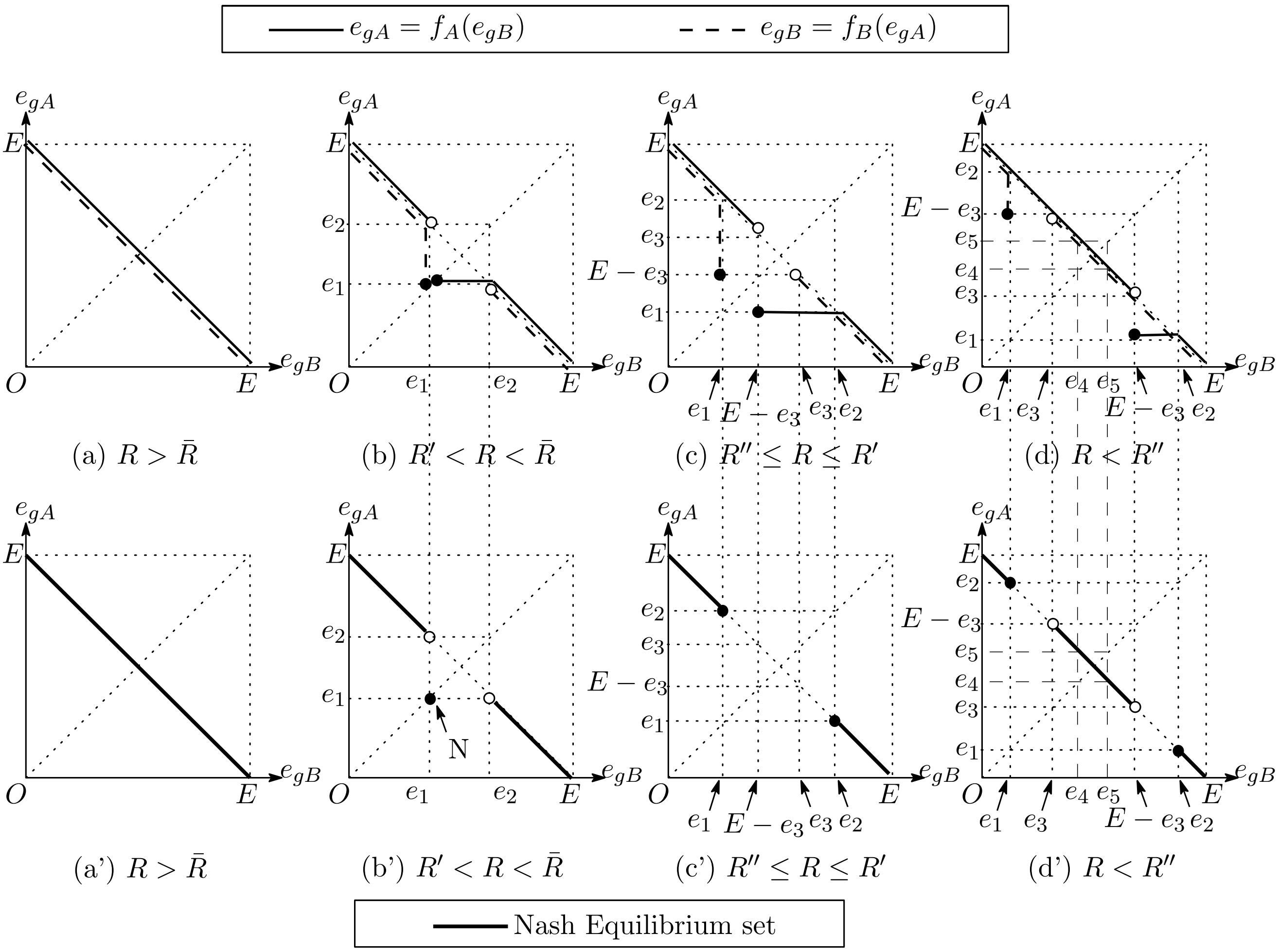

Figure 4: Nash emissions goal strategy set

$$
e_{gA} = f_A(e_{gB}) = \begin{cases}
E - e_{gB} & \text{for } e_{gB} \in [0, E] \qquad \text{if } R \geq \bar{R}, \\
\left.\begin{array}{ll} E - e_{gB} & \text{for } e_{gB} \in [0, e_1) \\ e_{1A} < E - e_{gB} & \text{for } e_{gB} \in [e_1, e_2) \\ E - e_{gB} & \text{for } e_{gB} \in [e_2, E] \end{array}\right\} & \text{if } R' \leq R < \bar{R}, \\
\left.\begin{array}{ll} E - e_{gB} & \text{for } e_{gB} \in [0, E - e_3) \\ e_{1A} < E - e_{gB} & \text{for } e_{gB} \in [E - e_3, e_2) \\ E - e_{gB} & \text{for } e_{gB} \in [e_2, E] \end{array}\right\} & \text{if } R < R'.
\end{cases} \tag{15}
$$

Again, $\bar{R}$ is the lobbying cost that equalizes the industry's cost under CP and that under

Quota, given in (6). Therefore, $\bar{R}$ is a border of whether the industry lobbies or not. When the lobbying cost is large enough such that $R \geq \bar{R}$, the emissions goal in country A satisfies $e_{gA} = E - e_{gB}$ for all $e_{gB} \in [0, E]$. Conversely, when $R < \bar{R}$, the industry changes a formerly decided instrument choice of CP to Quota by lobbying when e_{gB} is in $[e_1, e_2]$. These thresholds on emissions goal, e_1 and e_2, are given in (7). The policymaker can preempt the inefficient lobby and introduce CP by pledging the ambitious emissions goal at $e_{gA} = e_1$ for $e_{gB} \in [e_1, e_2]$. Otherwise, country A pledges $e_{gA} = E - e_{gB}$ for $E - e_{gB} \in [0, e_1)$ and $(e_2, E]$ which corresponds to $e_{gB} \in (e_2, E]$ and $[0, e_1)$. If the lobbying cost is further small such that $R \leq R'$, country A have other plans on setting emissions goals with respect to e_{gB}. R' is defined as a lobbying cost where the social cost under CP at e_1 and that under Quota at e_2 become equal, which is shown in (11). When $R < R'$, there exists a range of emissions goals where the social costs of CP with the ambitious emissions goal of $e_{gA} = e_1$ becomes greater than those of Quota with $e_{gA} = E - e_{gB}$. The boundary of this range is e_3 and shown in (12), on which the social cost under CP equals that under Quota at e_2. Therefore, the ambitious emissions goal of $e_{gA} = e_1$ preempts the lobby and reduces the social cost for $E - e_{gB} \in [e_1, e_3]$ which corresponds to $e_{gB} \in [E - e_3, e_2]$.

The symmetric reaction functions are held for country B. The reaction functions of the two countries are depicted in Figure 4(a) to Figure 4(d). Let us examine Nash equilibrium set for each case. Figure 4(a) depicts the reaction functions in a case where the lobbying cost is sufficiently large such that $R > R'$. As the reaction functions overlap for all $e_{g_A} \in [0, E]$ and $e_{g_B} \in [0, E]$, the Nash equilibrium set is a line of $e_{g_A} = E - e_{gB}$ for all range, as shown in Figure 4(a'). We then have the total social cost for the two countries $W = SC_P^A(e_{gA}) + SC_P^B(e_{gB})$ with $E = e_{gA} + e_{gB}$ and $E = \bar{e}$. As the social cost under CP for each country is linear with respect to the emissions goal as in (10), the total social cost for the two countries is constant at $W = c\bar{e}^2/2$ regardless of the breakdowns of the total emissions.

The reaction functions in a case with smaller lobbying costs such that $R' < R < \bar{R}$ are illustrated in Figure 4(b). The ambitious emissions goal is set to preempt domestic lobbying in both countries for $(e_{gA}, e_{gB}) = (e_1, e_1)$ for $[e_1, e_2)$. The instrument chosen in each country is CP for all the emissions goal of the other country. As the two countries are symmetric, the Nash equilibrium for this range appears only at $(e_{gA}, e_{gB}) = (e_1, e_1)$, which is point N in Figure 4(b'). As a result, $e_{gA} + e_{gB} = 2e_1 \leq E$ holds. The total social cost of the two countries when $(e_{gA}, e_{gB}) = (e_1, e_1)+$ is $W_1 = SC_P^A(e_1) + SC_P^B(e_1) = \frac{c\bar{e}^2}{2} + c\bar{e}\sqrt{\frac{\bar{e}^2}{4} - \frac{4R}{3c}}$. Otherwise, the total social cost is $W_0 = c\bar{e}^2/2$, which implies $W_1 \geq W_0$. Though a set of ambitious emissions goal remains in Nash equilibrium set as Point N in Figure 4(b'), this strategy set is Pareto inferior to the set of non-ambitious emissions goals. Discussion for this case yields the following.

Corollary 1 *The ambitious emissions goal may be a Nash equilibrium set in an international environmental agreement with two symmetric countries (Point N in Figure 4(b')).*

Figure 4(c) and (d) correspond to the case when $R < R'$. These two cases of (c) and (d) are divided by whether $E - e_3$ is greater than $E/2$ or not. This condition is equivalent to whether e_3 is greater than $E/2$ or not. As Assumption 1 implies $E = \bar{e}$, this threshold is derived by rearranging $e_3 = \bar{e}/2$ as

$$R'' = \frac{c\bar{e}^2}{8}(-3 + \sqrt{12}) \approx 0.058c\bar{e}^2 > 0. \tag{16}$$

When $R'' < R < R'$, the Nash equilibrium set appears on the non-ambitious emissions goal, $E = e_{gA} + e_{gB}$ for $[0, e_1]$ and $[e_2, E]$ as shown in Figure 4(c'). Although Quota is introduced for (e_3, e_2) as in Figure 2(b') from domestic political interactions, this case is ruled out from the Nash equilibrium set by considering international interactions. As a result, CP is introduced for on all of the Nash equilibrium sets. Figure 4(d') describes the case of $R \leq R''$. There are three Nash equilibrium sets of non-ambitious emissions goal for $[0, e_1]$, $(e_3, E - e_3)$, and $[e_2, E]$. Differently from the case of $R'' < R < R'$ shown in Figure 4(c) and (c'), whereas CP is introduced in the two end ranges of $[0, e_1]$ and $[e_2, E]$, Quota is introduced through lobbying in the middle range of $(e_3, E - e_3)$. However, $(e_3, E - e_3)$ contains a range (e_4, e_5) where Quota is socially preferred to CP as shown in Figure 3.

Corollary 2 *Quota may be introduced in the two symmetric countries. Then, Quota is socially preferred to CP, and the costly lobby is socially desired to correct the government's failure on instrument choice.*

4 Conclusion

The Paris agreement on climate change allows the contracting countries to set their nationally determined goals while sharing two goals: a global temperature rise of 1.5 degrees Celsius and well below 2 degrees Celsius. Facing this fact, rational policymakers may choose the easier goal to reduce costs. However, an increasing number of cities and countries have pledged to achieve the ambitious goals.

We define an ambitious emissions goal as a goal more stringent than a proposed emissions goal in an international environmental agreement. An ambitious emissions goal may then decrease the social cost by preempting the industry's lobby on the instrument choice. Naturally, ambitious emissions targets are usually set because of the altruism or benevolence of policymakers. The present study suggests that policymakers, in addition to setting an ambitious emissions goal due to their altruism or benevolence, can also set such a goal as a strategy.

In addition, we investigate a costly rent-seeking contest between the citizen and the industry for revenue refund from CP. Although CP is socially preferred to Quota in most cases, Quota becomes the socially preferred instrument when the contest is more costly than the industry's lobbying. We show that the policymaker initially chooses CP through the citizen's voting result, even if Quota is socially preferred. However, at the same time, the industry's lobby in instrument choice corrects this socially wrong choice.

Finally, we extend the political game in one country to that with two symmetric countries. Even in this extended game, a Nash equilibrium exists, where both countries pledge the ambitious emissions goals through the lobbying channel.

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