Greener Thy Neighbor? On the Welfare Effects of Protectionist Climate Policies

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The world is witnessing a surge in green industrial policies, with prominent examples such as the U.S. Inflation Reduction Act (IRA) incorporating significant protectionist elements. While economists have traditionally cautioned against protectionism due to its distortive effects, we argue that in the case of climate policies, these distortions can have strategic value by facilitating coordination between countries on climate action. We present a simple model that blends a standard abatement game with a beggar-thy-neighbor game, leading to multiple potential equilibria. Using techniques from the global games literature, we show that uncertainty surrounding the distortions caused by protectionist policies yields a unique equilibrium. We find that protectionist climate policies improve welfare when expected distortions are low, as they promote coordination on climate change mitigation at relatively modest costs. For high expected distortions, protectionist policies are welfare-neutral, as countries are unlikely to adopt them. For intermediate expected distortions, protectionist policies are most harmful, combining a high probability of coordination failure with substantial costs. Our findings suggest that regulators like the WTO could enhance global welfare by limiting, but not entirely banning, protectionist climate policies, especially in the absence of effective climate agreements.

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1. Introduction

Industrial policy has reemerged as a key topic in economic debates, with countries promoting industries critical to national security and the green transition toward sustainability (Juhász, Lane, and Rodrik 2023). In the U.S., the CHIPS and Science Act of 2022 aims to strengthen semiconductor research and manufacturing, reflecting this renewed focus. This revival of industrial policy has been analyzed extensively, particularly in the context of global semiconductor markets (Goldberg et al. 2024) and broader protectionist trends (Fajgelbaum et al. 2020).

The Inflation Reduction Act (IRA) of 2022, considered the most ambitious climate legislation in U.S. history (Bistline et al. 2023), directs $783 billion toward domestic energy security and climate change initiatives, positioning it as a leading example of green industrial policy (Altenburg and Rodrik 2017). Of this, $369 billion is earmarked for green subsidies, including tax credits and direct financial support, many of which apply exclusively to products made in North America. For example, $12 billion is allocated for electric vehicle incentives, but the subsidies of up to $7,500 are only available for vehicles assembled in North America.

Unsurprisingly, these protectionist measures have drawn criticism from several U.S. trading partners. The European Union (EU) has been particularly vocal, even considering legal action against the U.S. at the World Trade Organization (WTO) or retaliatory protectionist measures of its own (Fajeau et al. 2023). This has caused concerns about a potential 'green arms race,' where countries might engage in a zero-sum competition to attract international firms and capital (Kleimann et al. 2023; Gros, Mengel, and Presidente 2023; Dahlström et al. 2023; Sattich and Huang 2023).

Economists, by and large, have expressed discomfort with the protectionist components of the IRA. Historically, economists have been wary of industrial policies, highlighting risks such as beggar-thy-neighbor protectionism (Evenett 2019), the potential for rent-seeking, and the difficulties in selecting winning industries (Rodrik 2020). There are also concerns about trade frictions resulting from such policies (Irwin 2011), which could distort international supply chains and labor markets, ultimately leading to welfare losses (Canayaz, Erel, and Gurun 2024).

In this paper, we theoretically examine the welfare effects of protectionist climate policy. Our key insight is that protectionist green policy differs significantly from standard protectionist policy in one crucial respect: while beggar-thy-neighbor (BTN) policies typically create distortions, in the context of the green transition, these distortions may mitigate the lack of coordination in climate policies. More precisely, BTN elements in climate policy introduce strategic complementarity in a climate game that would otherwise be characterized by an underprovision of the global public good. In this sense, BTN distortions can counteract the coordination failures in climate action and may actually enhance social welfare. In related work, Fischer (2017) explores how interventionist green policies, often seen as distorting, might actually enhance global welfare—particularly in situations where implementing carbon prices is politically challenging, as noted by Juhász and Lane (2024).

We argue that there is a critical distinction between the CHIPS Act and the Inflation Reduction Act (IRA). Provisions designed to support the domestic production of non-public goods are essentially zero-sum, offering no increase in global welfare. However, provisions that encourage the domestic production of a public good—such as those in the IRA—may help to overcome the global underprovision of public goods by promoting coordination on the green transition, even though this comes with BTN distortions. The World Trade Organization (WTO) currently restricts industrial policies that distort trade, particularly subsidies. We suggest that in a second-best world, these restrictions may actually be detrimental to global welfare, as trade distortions could provide an effective pathway to tackling climate change. Our analysis is related to but distinct from the broader literature on the role of trade policy in international climate agreements, as explored by Ederington (2010), Farrokhi and Lashkaripour (2021), and Harstad (2024).

At its core, our work builds on the long-standing insight from the theory of the second best, originally outlined by Lipsey and Lancaster (1956). This theory posits that if eliminating a specific market distortion—such as externalities in public good provision—is impractical, introducing an additional distortion in related markets, such as BTN frictions, may offset the original distortion, potentially resulting in a more efficient outcome. The central question driving this paper is under what conditions protectionist climate policy can actually improve global welfare.

To clarify the relevant trade-offs and structure our analysis of the welfare effects of protectionist green policy, we model two identical countries that must decide whether to undergo the green transition, a binary action choice.[1] Each country's decision to

[1]There is a vast related literature that applies game theoretical tools to international environmental cooperation, see Finus (2000), Barrett (2005), and Wood (2011) for an overview. Ulph (2004), Kolstad (2007), and Barrett and Dannenberg (2012) study the stability of international environmental agreements under uncertainty. Zehaie (2009), Bayramoglu, Finus, and Jacques (2018), and Hritonenko, Hritonenko, and Yatsenko (2020) explore the role of adaptation and mitigation for international environmental cooperation. The stability of self-enforcing international environmental agreements is investigated in Barrett (1994), Rubio and Ulph (2007), de Zeeuw (2008), Heitzig, Lessmann, and Zou (2011), and Nordhaus (2021). Harstad

transition generates a positive externality for the other, as both benefit from reduced global emissions. Social welfare is maximized when both countries transition, but since the costs are privately borne and countries do not fully internalize the global benefits, they individually find it optimal not to transition. In this 'pure climate game,' not transitioning is the dominant strategy, resulting in a prisoner's dilemma where neither country transitions.

We extend this model to allow countries to implement protectionist policies during the green transition, introducing what we call the 'BTN climate game.' Here, countries can allocate a portion of their transition effort to beggar-thy-neighbor (BTN) policies, which we call BTN effort. In this game, a country can extract a resource transfer from the other if its BTN effort exceeds that of the other. However, BTN effort incurs a cost, denoted by κ, which reflects the welfare loss from supply chain distortions and the rising cost of goods caused by protectionist measures.

We first consider the case where BTN costs κ are known. If these costs are sufficiently low, both countries will find it optimal to transition with full protectionism. For high values of κ, the dominant strategy is not to transition. At intermediate values of κ, the BTN climate game exhibits multiple equilibria: a country will transition if the other does and will not transition if the other does not. This multiplicity stems from the fact that the payoffs from transitioning increase and are convex in the number of countries transitioning. At intermediate BTN costs, transitioning is attractive only if the other country transitions, creating a coordination problem and resulting in multiple equilibria.

A fundamental issue in the real world is that the welfare costs from BTN-induced trade distortions are uncertain. We introduce this uncertainty in the model by assuming both countries share a common prior belief about the true BTN cost parameter before making their transition decision. Each country then receives a private signal about the cost and updates its belief accordingly. This framework leads to a global game in the sense of Carlsson and Van Damme (1993). We demonstrate that under mild conditions, the game with uncertain BTN costs has a unique equilibrium in switching strategies.[2]

(2012), Nordhaus (2015), and Martimort and Sand-Zantman (2016) provide insights into the design of optimal climate contracts. Fields and Lindequist (2022) empirically investigate the existence of climate policy risk spillovers from the US to the EU.

[2]These conditions reflect those in Morris and Shin (2000). Also see Morris and Shin (2003), Frankel, Morris, and Pauzner (2003), Jorge and Rocha (2015), and Morris (2016) for discussions on global game methodology. Applications of this methodology to climate change cooperation are rare, with Heijmans (2022) and Heijmans (2023) being notable exceptions. These papers focus on network externalities and do not examine the strategic complementarities arising from protectionist policies.

If countries believe BTN costs are low, they will transition; if they believe the costs are high, they will not. As is typical in global games, this uncertainty combined with sufficiently precise private signals eliminates the multiplicity of equilibria found in the coordination game. The unique equilibrium provides a probability distribution over the possible payoffs of the BTN climate game, allowing us to derive comparative statics for expected welfare based on the model parameters.

We find that the expected welfare in the unregulated BTN climate game is non-monotonic in the mean of the prior belief about BTN cost parameter κ. When expected BTN costs are very low, both countries will almost certainly transition with full protectionism, leading to welfare that exceeds the payoff from the pure climate game. In this case, it is socially efficient to endure BTN costs for the sake of the green transition. When BTN costs are very high, neither country will transition, which is also efficient, as the costs of trade distortions outweigh the benefits of transitioning. However, for intermediate BTN costs, welfare can be lower than in the pure climate game. This occurs for one of two reasons. First, if welfare improves when both countries transition but not when only one does, intermediate BTN costs create a high probability that only one country will transition, reducing welfare relative to the pure climate game. Second, if expected BTN costs are just high enough to make full protectionist transitions undesirable, the likelihood of both countries transitioning remains relatively high, resulting in a welfare loss compared to the pure climate game.

While the BTN climate game can lead to a welfare improvement over the pure climate game, the zero-sum nature of BTN transfers means that more protectionist policy is implemented in equilibrium than is necessary to incentivize transitions. We show that a regulator who controls the level of protectionist policy can improve expected welfare. By reducing the extent of BTN policies in the BTN game, a regulator can increase the welfare benefits of the game over the pure climate game, provided expected BTN costs are not excessively high.

In terms of policy conclusions, our results suggest that the WTO should be restrictive toward protectionist climate policies when their expected distortions are of intermediate size, as this creates a high risk of costly coordination failures, making the use of such policies too expensive for facilitating the green transition. However, when expected distortions are low, the WTO should permit some protectionist measures to support the green transition. In contrast, when expected distortions are high, strict WTO regulation becomes less critical, as countries are unlikely to adopt protectionist climate policies due to their prohibitive costs.

The rest of this paper is organized as follows. Section 2 presents the basic model setup. In Section 3, we analyze the global game resulting from uncertainty about the welfare costs of protectionist policy. We derive our main results regarding the welfare effects of protectionist policy in Section 4. Section 5 concludes.

2. Model Setup

Consider an economy comprising two countries, denoted as country i and country j. Each country has a binary abatement ('green transition') choice $a_i = \{0, 1\}$, where $a_i = 0$ signifies 'no abatement' and $a_i = 1$ denotes 'abatement'. Furthermore, each country can select a level of protectionism per unit of abatement: $\alpha_i \in [0, 1]$, with $\alpha_i = 0$ indicating no protectionism and $\alpha_i = 1$ representing full protectionism, i.e., each unit of abatement is protectionist. For instance, if 30% of climate policy spending in country i is protectionist in nature, then $\alpha_i = 0.3$.

The total level of protectionism by country i is denoted by

$$\tau_i = \alpha_i a_i = \begin{cases} \alpha_i & \text{if } a_i = 1 \\ 0 & \text{if } a_i = 0 \end{cases} \tag{1}$$

In the event that country i adopts a greater level of protectionism compared to country j, as indicated by $\tau_i > \tau_j$, country i can obtain a resource transfer from country j. This representation highlights the intention of protectionist policies to favor domestic production at the expense of foreign production or to draw foreign capital. Following Rodrik (2020), we assume a reduced-form zero-sum transfer function of the form:

$$T_i(\tau_i, \tau_j) = \begin{cases} 0 & \text{if } a_i = a_j = 0 \\ \alpha_i & \text{if } a_i = 1, a_j = 0 \\ -\alpha_j & \text{if } a_i = 0, a_j = 1 \\ \alpha_i - \alpha_j & \text{if } a_i = a_j = 1 \end{cases} \tag{2}$$

which implies that $T_i(\tau_i, \tau_j) + T_j(\tau_i, \tau_j) = 0$. Moreover, we assume that 'beggar-thy-neighbor' (BTN) policies incur a private cost that is linearly related to the level of protectionism: $\kappa_i(\tau_i) = \kappa_i \tau_i$ where $\kappa_i \in (0, 1)$. These costs serve as a simplified representation of the distortions stemming from mercantilist policies that lead to efficiency losses in international trade or capital allocation.[3]

Climate mitigation serves as a public good from which both countries benefit. Let $\gamma_i u(G)$ represent the utility country i derives from public good $G = a_A + a_B$. The parameter $\gamma_i > 0$ reflects country i's enjoyment of the public good. Alternatively, it represents the damages country i experiences from unmitigated climate change.

We assume that the utility derived from the public good is increasing in its overall provision: $u(2) > u(1) > u(0)$. Crucially, we further assume that the marginal effect of climate change mitigation increases in the number of abating countries: $u(2) - u(1) > u(1) - u(0)$. Intuitively, joint efforts lead to more effective results than isolated actions. This assumption highlights the importance of international cooperation in addressing climate change, as the benefits of such cooperation are significantly higher than if each country were to act alone. Relatedly, tipping points in the context of climate change refer to critical thresholds at which a small change in environmental conditions can lead to a significant and often irreversible change in the ecosystem. As the number of countries engaged in mitigation increases, the effectiveness of these efforts grows disproportionately. This non-linearity reflects how avoiding tipping points can prevent disproportionately large negative impacts. If fewer countries engage in mitigation, the world risks crossing these tipping points, leading to severe and possibly irreversible environmental consequences.

Climate policies entail a private cost, denoted by $c_i(a_i)$. For simplicity, assume that the cost function is linear: $c_i(a_i) = c_i a_i$, where $c_i > 0$ indicates country i's cost of climate policy implementation. This cost may be high either because a country is relatively poor, making climate change mitigation particularly costly in terms of opportunity costs of resource allocation, or because it is technologically challenging for that country to reduce emissions.

The welfare function of country i is given by

$$W_i = \gamma_i u(G) - c_i a_i - \kappa_i \tau_i + T_i(\tau_i, \tau_j) \tag{3}$$

where $G = a_i + a_j$ and $\tau_i = \alpha_i a_i$. For the remainder of the analysis, we will assume that countries are identical, i.e., $c_i = c_j = c$ and $\gamma_i = \gamma_j = \gamma$. We make the following crucial assumption:

Assumption 1. *Let there be $N = 2$ countries in the economy. It holds true for each country*

[3] For instance, conditioning subsidies on EVs to require battery production within the US could potentially raise the subsidies required to promote EV purchases compared to a scenario where all EVs receive subsidies, irrespective of battery origin.

that it is always privately inefficient but socially efficient to abate:

$$\gamma\left[u(1)-u(0)\right] < c < 2\gamma\left[u(1)-u(0)\right],$$
$$\gamma\left[u(2)-u(1)\right] < c < 2\gamma\left[u(2)-u(1)\right].$$

Note that since $u(2)-u(1) > u(1)-u(0)$, these two assumptions can be succinctly written as

$$\gamma\left[u(2)-u(1)\right] < c < 2\gamma\left[u(1)-u(0)\right].$$

Furthermore, both countries abating is socially efficient:

$$2\gamma u(2) - 2c > 2\gamma u(0)$$

which is guaranteed by assuming that $\gamma\left[u(2)-u(0)\right] > c$.

The payoff matrix of the climate game with protectionist policy is presented in Table 1.

		Player j: $a_j = 1$	Player j: $a_j = 0$
Player i	$a_i = 1$	$\gamma u(2) - c - \kappa\alpha_i$, $\gamma u(2) - c - \kappa\alpha_j$	$\gamma u(1) - c - \kappa\alpha_i + \alpha_i$, $\gamma u(1) - \alpha_i$
	$a_i = 0$	$\gamma u(1) - \alpha_j$, $\gamma u(1) - c - \kappa\alpha_j + \alpha_j$	$\gamma u(0)$, $\gamma u(0)$

TABLE 1. Payoffs in Climate Game with Protectionist Policy

2.1. Pure climate game

To fix ideas, first consider a pure climate game without BTN policies. Assumption 1 guarantees that each country's dominant strategy is to choose $a_i = 0$, meaning not to abate. Consequently, countries will face a prisoner's dilemma: no individual country perceives abatement as privately optimal, and thus, $G = 0$ emerges as the unique Nash equilibrium. In contrast, the socially efficient outcome would be $G = 2$. Due to misaligned private and social incentives, the Nash equilibrium results in inefficiency. The following Lemma summarizes these insights.

LEMMA 1 (Nash equilibrium of pure climate game). *In the absence of protectionism ($\alpha_i = \alpha_j = 0$), the unique Nash equilibrium of the climate game is characterized by $a_i = a_j = 0$, resulting in $G = 0$. This equilibrium is Pareto-dominated by $a_i = a_j = 1$, yielding $G = 2$.*

2.2. BTN climate game with unregulated protectionism and known κ

As another benchmark, consider the game in which countries can freely choose their level of protectionism α_i and in which the BTN cost parameter κ is common knowledge.

The payoff function in eq. (3) is such that the marginal cost of BTN policies is given by κ, while the transfer function in eq. (2) indicates that the marginal benefit of BTN policies is equal to one. Note that the linearity of the transfer function implies that if a country opts to abate, it will do so with fully protectionist climate policies (i.e., $\alpha = 1$).

Country i finds it optimal to abate with full protectionism if

$$\gamma u(2) - c - \kappa > \gamma u(1) - 1 \qquad \text{if } a_j = 1 \tag{4}$$

$$\gamma u(1) - c + (1 - \kappa) > \gamma u(0) \qquad \text{if } a_j = 0 \tag{5}$$

As a result, abatement is a dominant strategy if $\kappa < 1 + \gamma\left[u(1) - u(0)\right] - c \equiv \underline{\kappa}$, while no abatement is a dominant strategy if $\kappa > 1 + \gamma\left[u(2) - u(1)\right] - c \equiv \overline{\kappa}$ where $0 < \underline{\kappa} < \overline{\kappa} < 1$. For $\kappa \in (\underline{\kappa}, \overline{\kappa})$, country i wants to abate if country j abates and wants to not abate if country j does not play abate. That is, the interval $(\underline{\kappa}, \overline{\kappa})$ presents a '*window of complementarity*', in which there are two equilibria: ($a_i = 1, a_j = 1$) and ($a_i = 0, a_j = 0$). In this case, the BTN climate game becomes a stag hunt, a class of games of strategic complementarity with multiple equilibria. Figure 1 illustrates equilibrium play as a function of the BTN cost parameter κ.

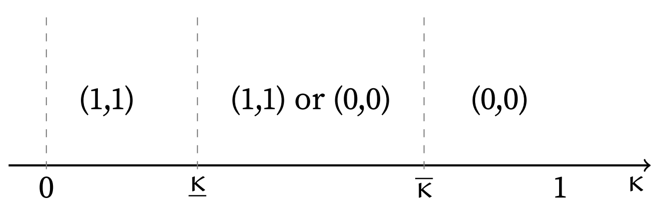

FIGURE 1. BTN Climate Game with Perfect Information – Equilibrium Play

In terms of welfare, the BTN climate game with unregulated protectionism is such that an equilibrium in which both countries abate welfare-dominates an equilibrium in which only one country abates if

$$2\gamma u(2) - 2c - 2\kappa > 2\gamma u(1) - c - \kappa \tag{6}$$

$$\iff \kappa < 2\gamma\left[u(2) - u(1)\right] - c \equiv \overline{\kappa}^w \tag{7}$$

Similarly, an equilibrium in which one country abates welfare-dominates an equilibrium in which no country abates if

$$2\gamma u(1) - c - \kappa > 2\gamma u(0) \tag{8}$$

$$\iff \kappa < 2\gamma\left[u(1) - u(0)\right] - c \equiv \underline{\kappa}^w \tag{9}$$

where $\overline{\kappa}^w > \underline{\kappa}^w$ due to our assumption on payoffs. Finally, the BTN climate game with unregulated protectionism in which both countries abate welfare-dominates the prisoner's dilemma of the pure climate game if

$$2\gamma u(2) - 2c - 2\kappa > 2\gamma u(0) \tag{10}$$

$$\iff \kappa < \gamma\left[u(2) - u(0)\right] - c \equiv \kappa^w \tag{11}$$

where $\kappa^w = \frac{1}{2}\underline{\kappa}^w + \frac{1}{2}\overline{\kappa}^w$ which also implies that $\underline{\kappa}^w < \kappa^w < \overline{\kappa}^w$. Let $W(a_i, a_j)$ denote the social welfare function associated with outcome $a_i \in \{0, 1\}$ and $a_j \in \{0, 1\}$. From a social welfare perspective, the preference ordering over the four different outcomes of the game, $\{(0, 0), (0, 1), (1, 0), (1, 1)\}$, depend on the value of κ as follows:

$$\text{If } \kappa < \underline{\kappa}^w: \quad W(1, 1) > W(1, 0) = W(0, 1) > W(0, 0) \tag{12}$$

$$\text{If } \kappa \in \left(\underline{\kappa}^w, \kappa^w\right): \quad W(1, 1) > W(0, 0) > W(1, 0) = W(0, 1) \tag{13}$$

$$\text{If } \kappa \in \left(\kappa^w, \overline{\kappa}^w\right): \quad W(0, 0) > W(1, 1) > W(1, 0) = W(0, 1) \tag{14}$$

$$\text{If } \kappa > \overline{\kappa}^w: \quad W(0, 0) > W(1, 0) = W(0, 1) > W(1, 1) \tag{15}$$

Figure 2 illustrates. Intuitively, it is welfare optimal if both countries play abate if $\kappa < \kappa^w$, while it is welfare optimal if no country abates if $\kappa > \kappa^w$. It is never welfare-optimal for just one country to abate. However, an outcome in which only one country abates improves welfare over an outcome in which no country abates if $\kappa < \underline{\kappa}^w$. It also improves welfare over an outcome in which both countries abate if $\kappa > \overline{\kappa}^w$. The outcome of only one country abating is welfare-minimizing for $\kappa \in \left(\underline{\kappa}^w, \overline{\kappa}^w\right)$.

These cutoffs for welfare orderings do not coincide with those for equilibrium play

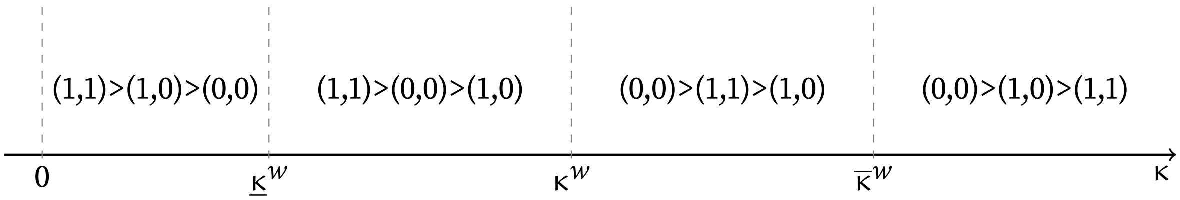

FIGURE 2. BTN Climate Game with Perfect Information – Welfare Ordering

derived earlier. More specifically,

$$\text{If } \gamma(u(1) - u(0)) < 1 < \gamma(u(2) - u(1)) : \qquad \kappa^w \in [\underline{\kappa}, \overline{\kappa}] \tag{16}$$

$$\text{If } \gamma(u(1) - u(0)) > 1 : \qquad \kappa^w > \overline{\kappa} \tag{17}$$

$$\text{If } \gamma(u(2) - u(1)) < 1 : \qquad \kappa^w < \underline{\kappa} \tag{18}$$

If $\kappa > \max\{\kappa^w, \overline{\kappa}\}$, neither country should abate, and none will. Conversely, if $\kappa < \min\{\kappa^w, \underline{\kappa}\}$, both countries should abate, and they do. For intermediate values of κ, inefficiency may occur if countries fail to coordinate their actions toward the efficient outcome.

Note that the outcome of just one country abating can never be a Nash equilibrium in the game with perfect information. In a game with imperfect knowledge about the BTN cost parameter κ, however, the BTN game with unregulated protectionism may yield such an equilibrium, as we will see in the next section.

3. Uncertainty about Beggar-Thy-Neighbor Costs

Consider the setup as before. Suppose that there is uncertainty about the cost associated with BTN policies, i.e., uncertainty about the cost parameter κ. This parameter is common among both players. The 'true state of the world' is given by $z \in (-\infty, +\infty)$, which translates into the BTN cost parameter as follows:

$$\kappa = \zeta \exp(z) \tag{19}$$

where $\zeta > 0$ is a scale parameter. This functional form ensures that $\kappa \in (0, \infty)$. Suppose that the true state of the world z is a random variable that is distributed with mean $\bar{z}$ and precision σ_z (i.e., variance $1/\sigma_z$): $z \sim \mathcal{N}(\bar{z}, 1/\sigma_z)$. This implies that the distribution of the BTN cost parameter κ is log-normal, i.e., its logarithm is normally distributed:

$\ln(\kappa) = \ln(\zeta) + z$. Thus, the random variable κ has a probability density function given by

$$f(\kappa) = \frac{\sqrt{\sigma_z}}{\kappa\sqrt{2\pi}} \exp\left(-\frac{1}{2}\sigma_z\left(\ln(\kappa) - \ln(\zeta) - \bar{z}\right)^2\right) \tag{20}$$

This implies that the random variable $\ln(\kappa)$ is normally distributed with mean $\ln(\zeta) + \bar{z}$ and variance $1/\sigma_z$ (or precision σ_z). Furthermore, by the properties of the log-normal distribution, it holds that

$$\mathbb{E}(\kappa) = \zeta \exp\left(\bar{z} + \frac{1}{2\sigma_z}\right) \tag{21}$$

$$Var(\kappa) = \zeta^2 \left(\exp\left(\frac{1}{\sigma_z}\right) - 1\right) \exp\left(2\bar{z} + \frac{1}{\sigma_z}\right) \tag{22}$$

These expressions provide a tractable map from beliefs about the true state of the world z to beliefs about the BTN cost parameter κ.

3.1. Beliefs and information

Now suppose that there is uncertainty about the true state of the world z and, as a result, uncertainty about the BTN cost parameter κ. As before, z is a random variable with mean $\bar{z}$ and precision σ_z (i.e., variance $1/\sigma_z$): $z \sim \mathcal{N}(\bar{z}, 1/\sigma_z)$. Players have access to very precise information z before making their abatement decision, but the information is not perfect. Player i observes a private realization of the signal about z: $x_i = z + \epsilon_i$ where ϵ_i is normally distributed with mean 0 and precision σ_ϵ: $\epsilon_i \sim \mathcal{N}(0, 1/\sigma_\epsilon)$. The signals are independent across players.

A strategy for a player is a rule of action that prescribes an action for each realization of the signal. A profile of strategies (one for each player) is an equilibrium if, conditional on the information available to player i and given the strategy followed by player j, the action prescribed by i's strategy maximizes his conditional expected utility. Treating such realization of i's signal as a possible 'type' of the player, we are solving for the Bayes Nash equilibrium of the imperfect-information game.

Player i uses the signal x_i to update his belief about the distribution of random variable z using Bayes rule. Since both z and x_i are normally distributed, the mean of player i's posterior belief distribution about z upon observing signal x_i is given by

$$\rho_i = \frac{\sigma_z \bar{z} + \sigma_\epsilon x_i}{\sigma_z + \sigma_\epsilon}. \tag{23}$$

Specifically, conditional on signal x_i, state z is normal with mean ρ_i and precision $\sigma_z+\sigma_\epsilon$, i.e., $z|x_i \sim \mathcal{N}\left(\rho_i, \frac{1}{\sigma_z+\sigma_\epsilon}\right)$. Since $x_j = z + \epsilon_j$, the distribution of x_j conditional on ρ_i is normal with mean ρ_i and precision

$$\frac{1}{\frac{1}{\sigma_z+\sigma_\epsilon} + \frac{1}{\sigma_\epsilon}} = \frac{\sigma_\epsilon(\sigma_z + \sigma_\epsilon)}{\sigma_z + 2\sigma_\epsilon} \tag{24}$$

That is,

$$x_j|\rho_i \sim \mathcal{N}\left(\rho_i, \frac{\sigma_z + 2\sigma_\epsilon}{\sigma_\epsilon(\sigma_z + \sigma_\epsilon)}\right) \tag{25}$$

Furthermore,

$$\rho_j = \frac{\sigma_z \bar{z} + \sigma_\epsilon x_j}{\sigma_z + \sigma_\epsilon} \tag{26}$$

The corresponding belief about the true BTN cost parameter κ is then given by

$$\ln(\kappa)|x_i \sim \mathcal{N}\left(\rho_i, \frac{1}{\sigma_z + \sigma_\epsilon}\right) \tag{27}$$

so that

$$\hat{\kappa}_i = \mathbb{E}(\kappa|x_i) = \zeta \exp\left(\rho_i + \frac{1}{2(\sigma_z + \sigma_\epsilon)}\right) \tag{28}$$

$$Var(\kappa|x_i) = \zeta^2 \left(\exp\left(\frac{1}{\sigma_z + \sigma_\epsilon}\right) - 1\right) \exp\left(2\rho_i + \frac{1}{\sigma_z + \sigma_\epsilon}\right) \tag{29}$$

We then see that

$$\frac{\partial \hat{\kappa}_i}{\partial \rho_i} = \zeta \exp\left(\rho_i + \frac{1}{2(\sigma_z + \sigma_\epsilon)}\right) > 0 \tag{30}$$

$$\frac{\partial \hat{\kappa}_i}{\partial \sigma_z} = -\frac{\zeta \exp\left(\rho_i + \frac{1}{2(\sigma_z+\sigma_\epsilon)}\right)}{2(\sigma_\epsilon + \sigma_z)^2} < 0 \tag{31}$$

$$\frac{\partial \hat{\kappa}_i}{\partial \sigma_\epsilon} = -\frac{\zeta \exp\left(\rho_i + \frac{1}{2(\sigma_z+\sigma_\epsilon)}\right)}{2(\sigma_\epsilon + \sigma_z)^2} < 0 \tag{32}$$

Intuitively, a larger posterior belief about the state z (given by ρ_i) translates into a higher belief about the BTN cost parameter. In addition, higher precision of either the prior distribution (higher σ_z) or the signal distribution (higher σ_ϵ) leads to smaller posterior beliefs about the BTN cost parameter, i.e., reduced uncertainty very tractably reduces the mean of the posterior belief distribution about the BTN cost parameter κ.

Note that for agent i the probability that agent j has a mean belief ρ_j less than some cutoff value $\hat{\rho}_j$ is given by

$$
\begin{aligned}
q \equiv \text{Prob}(\rho_j < \hat{\rho}_j | \rho_i) &= \text{Prob}\left(\frac{\sigma_z \bar{z} + \sigma_\epsilon x_j}{\sigma_z + \sigma_\epsilon} < \hat{\rho}_j | \rho_i\right) \\
&= \text{Prob}\left(x_j < \hat{\rho}_j + \frac{\sigma_z}{\sigma_\epsilon}(\hat{\rho}_j - \bar{z}) | \rho_i\right) \\
&= \Phi\left(\sqrt{\frac{\sigma_\epsilon(\sigma_z + \sigma_\epsilon)}{\sigma_z + 2\sigma_\epsilon}}\left(\hat{\rho}_j + \frac{\sigma_z}{\sigma_\epsilon}(\hat{\rho}_j - \bar{z}) - \rho_i\right)\right) \\
&= \Phi\left(\sqrt{\beta}\left(\hat{\rho}_j - \rho_i + \frac{\sigma_z}{\sigma_\epsilon}(\hat{\rho}_j - \bar{z})\right)\right) \qquad (33)
\end{aligned}
$$

where $\Phi(\cdot)$ is the cdf of the standard normal distribution and where $\beta \equiv \frac{\sigma_\epsilon(\sigma_z + \sigma_\epsilon)}{\sigma_z + 2\sigma_\epsilon}$ is the precision of the belief of player i about player j's signal given player i's signal.

Now, suppose player i was sure that player j was going to follow a 'threshold' strategy where she abated only if the mean of her posterior belief of the true state of the world z was below $\hat{\rho}_j$, which means that

$$
s_j(\rho_j) = \begin{cases} a_j = 0, & \text{if } \rho_j > \hat{\rho}_j \\ a_j = 1, & \text{if } \rho_j < \hat{\rho}_j. \end{cases} \qquad (34)
$$

Under this strategy, player j will not abate if her posterior belief about the state z is sufficiently high so that her belief about the BTN cost parameter κ is sufficiently high as well (as a high z implies a high κ).

Let $b_i(\hat{\rho}_j)$ denote player i's best response threshold strategy where for all $\rho_i \leq b_i(\hat{\rho}_j)$ player i will abate:

$$
\begin{aligned}
& q\left[\gamma u(2) - c + (1 - \hat{\kappa}_i) - 1\right] + (1-q)\left[\gamma u(1) - c + (1 - \hat{\kappa}_i)\right] \geq q\left[\gamma u(1) - 1\right] + (1-q)\left[\gamma u(0)\right] \\
\iff & \gamma\left[q\left(u(2) - u(1)\right) + (1-q)\left(u(1) - u(0)\right)\right] - c + (1 - \hat{\kappa}_i) \geq 0, \qquad (35)
\end{aligned}
$$

and where for all $\rho_i > b_i(\hat{\rho}_j)$ player i will not abate:

$$
\gamma\left[q\left(u(2) - u(1)\right) + (1-q)\left(u(1) - u(0)\right)\right] - c + (1 - \hat{\kappa}_i)\alpha_i < 0, \qquad (36)
$$

where $\hat{\kappa}_i$ is player i's expectation of the BTN cost parameter implied by his signal x_i: $\hat{\kappa}_i = \mathbb{E}(\kappa|x_i) = \zeta \exp\left(\rho_i + \frac{1}{2(\sigma_z+\sigma_\epsilon)}\right)$. Intuitively, as x_i goes up, ρ_i goes up and therefore the expected value of the BTN cost goes up. As a result, x_i has two effects. First, it increases player i's expected value of the BTN cost parameter $\hat{\kappa}_i$, which makes abatement relatively less attractive. Importantly, the strength of this effect depends on player i's level of protectionism α_i. Second, it increases the probability that player i attaches to the probability that player j observes a signal larger than her threshold value $\hat{\rho}_j$ and thus increases the probability that player j does not abate. This makes abatement less attractive for player i as well.

In the case of player i, the left-hand side of eq. (35) is the net expected gain from abatement which is given by

$$F \equiv \underbrace{\gamma\left[q\left[u(2)-u(1)\right]+(1-q)\left[(u(1)-u(0))\right]\right]+(1-\hat{\kappa}_i)}_{\text{expected gain from abatement}} - \underbrace{c}_{\text{cost of abatement}}. \tag{37}$$

The best response cut-off strategy for player i is one that sets $F = 0$ at $\rho_i = b_i(\hat{\rho}_j)$ for a given cutoff $\hat{\rho}_j$.

3.2. Existence and uniqueness of equilibrium

Note that the net expected gain from abatement for player i can be rewritten as

$$\begin{aligned}
& F \equiv \gamma\left[q\left[u(2)-u(1)\right]+(1-q)\left[(u(1)-u(0))\right]\right]+(1-\hat{\kappa}_i)-c=0 \\
\iff\quad & \hat{\kappa}_i = 1+\gamma\left[q\,(u(2)-u(1))+(1-q)\,(u(1)-u(0))\right]-c \\
& \quad = q\left[1+\gamma\,(u(2)-u(1))-c\right]+(1-q)\left[1+\gamma_1\,(u(1)-u(0))-c\right] \\
& \quad = q\overline{\kappa}+(1-q)\underline{\kappa}
\end{aligned}$$

$$\implies\quad \hat{\kappa}_i = \underline{\kappa}+q\,(\overline{\kappa}-\underline{\kappa}) \tag{38}$$

where $\hat{\kappa}_i$ denotes the marginal BTN cost while $\underline{\kappa}+q\,(\overline{\kappa}-\underline{\kappa})$ denotes the marginal BTN benefit.

Given our analysis above, we know that

$$\overline{\kappa} = 1+\gamma\left[u(2)-u(1)\right]-c, \quad \underline{\kappa} = 1+\gamma\left[u(1)-u(0)\right]-c$$
$$\hat{\kappa}_i = \mathbb{E}(\kappa|x_i) = \zeta\exp\left(\rho_i+\frac{1}{2(\sigma_z+\sigma_\epsilon)}\right)$$

$$q = \text{Prob}(\rho_j < \hat{\rho}_j | \rho_i) = \Phi\left(\sqrt{\beta}\left(\hat{\rho}_j - \rho_i + \frac{\sigma_z}{\sigma_\epsilon}(\hat{\rho}_j - \bar{z})\right)\right)$$

where $\beta = \frac{\sigma_\epsilon(\sigma_z+\sigma_\epsilon)}{\sigma_z+2\sigma_\epsilon}$ is the precision of the belief of player i about player j's signal given player i's signal. As a result, the equilibrium threshold ρ_i^* solves

$$\zeta \exp\left(\rho_i^* + \frac{1}{2(\sigma_z+\sigma_\epsilon)}\right) = \underline{\kappa} + \Phi\left(\sqrt{\beta}\left(\hat{\rho}_j - \rho_i^* + \frac{\sigma_z}{\sigma_\epsilon}(\hat{\rho}_j - \bar{z})\right)\right)(\overline{\kappa} - \underline{\kappa}) \tag{39}$$

Using the fact that in a symmetric equilibrium $\rho_i^* = \rho_j^* = \rho^*$, the equilibrium threshold solves

$$\underbrace{\zeta \exp\left(\rho^* + \frac{1}{2(\sigma_z+\sigma_\epsilon)}\right)}_{=LHS} = \underbrace{\underline{\kappa}_1 + \Phi\left(\sqrt{\frac{\sigma_\epsilon(\sigma_z+\sigma_\epsilon)}{\sigma_z+2\sigma_\epsilon}}\frac{\sigma_z}{\sigma_\epsilon}(\rho^* - \bar{z})\right)(\overline{\kappa}_1 - \underline{\kappa}_1)}_{=RHS} \tag{40}$$

Proposition 1. *Suppose Assumptions 1 holds. Then, if* $\theta \leq 2\pi\left(\frac{\underline{\kappa}}{\overline{\kappa}-\underline{\kappa}}\right)^2$ *there exists a unique equilibrium* ρ^* *where the unique equilibrium,* ρ^**, satisfies,*

$$\zeta \exp\left(\rho^* + \frac{1}{2(\sigma_\epsilon+\sigma_z)}\right) = \underline{\kappa} + \Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)(\overline{\kappa} - \underline{\kappa}). \tag{41}$$

where $\theta = \beta\frac{\sigma_z^2}{\sigma_\epsilon^2}$ *and* $\beta = \frac{\sigma_\epsilon(\sigma_z+\sigma_\epsilon)}{\sigma_z+2\sigma_\epsilon}$.

Proof. Consider equilibrium condition eq. (40) for the cut-off strategy of a player. Note that ρ^* is bounded above and below by $\overline{\rho}$ and $\underline{\rho}$ respectively where $\overline{\rho}$ solves

$$\zeta \exp\left(\rho^* + \frac{1}{2(\sigma_\epsilon+\sigma_z)}\right) = \overline{\kappa}, \tag{42}$$

and $\underline{\rho}$ solves

$$\zeta \exp\left(\rho^* + \frac{1}{2(\sigma_\epsilon+\sigma_z)}\right) = \underline{\kappa}. \tag{43}$$

We know $\overline{\rho}$ and $\underline{\rho}$ always exists and $\overline{\rho} < \underline{\rho}$ because we know $(\underline{\kappa}, \overline{\kappa}) \subset (0, \infty)$ by assumption and the left-hand side of eq. (40) is a continuous strictly increasing function of ρ, taking all values between 0 and ∞ in its domain. Further, the right-hand side of eq. (40) is a strictly increasing function in ρ whose lower and upper bound are $\underline{\kappa}$ and $\overline{\kappa}$ respectively.

Therefore, if the difference between the left-hand side (LHS) and right-hand side (RHS) of eq. (40) strictly increases with ρ it is a sufficient condition for a single crossing between the left-hand side and the right-hand side. For this condition we require $\forall \rho \in (\underline{\rho}, \overline{\rho})$,

$$\frac{\partial LHS}{\partial \rho} - \frac{\partial RHS}{\partial \rho} > 0. \tag{44}$$

Note, that a sufficiency condition for eq. (44) to hold is if within the domain $\rho \in [\underline{\rho}, \overline{\rho}]$ we have

$$\inf_{\rho \in [\underline{\rho}, \overline{\rho}]} \left(\frac{\partial LHS}{\partial \rho} \right) - \sup_{\rho \in [\underline{\rho}, \overline{\rho}]} \left(\frac{\partial RHS}{\partial \rho} \right) > 0. \tag{45}$$

Specifically,

$$\begin{aligned}
&\inf_{\rho \in [\underline{\rho}, \overline{\rho}]} \left(\zeta \exp\left(\rho^* + \frac{1}{2(\sigma_\epsilon + \sigma_z)} \right) \right) - \sup_{\rho \in [\underline{\rho}, \overline{\rho}]} \left(\sqrt{\theta} \phi \left(\sqrt{\theta} (\rho^* - \bar{z}) \right) (\overline{\kappa} - \underline{\kappa}) \right) > 0 \\
\Leftrightarrow\ &\underbrace{\inf_{\rho \in [\underline{\rho}, \overline{\rho}]} \left(\zeta \exp\left(\rho^* + \frac{1}{2(\sigma_\epsilon + \sigma_z)} \right) \right)}_{=\underline{\kappa}} - \underbrace{\sup_{\rho \in [\underline{\rho}, \overline{\rho}]} \left((\overline{\kappa} - \underline{\kappa}) \sqrt{\frac{\theta}{2\pi}} \exp\left(-\frac{\theta}{2} (\rho - \bar{z})^2 \right) \right)}_{=(\overline{\kappa} - \underline{\kappa})\sqrt{\frac{\theta}{2\pi}}} > 0 \\
&\Leftrightarrow \underline{\kappa} - (\overline{\kappa} - \underline{\kappa}) \sqrt{\frac{\theta}{2\pi}} > 0 \\
&\Longrightarrow \underbrace{\frac{\underline{\kappa}\sqrt{2\pi}}{\overline{\kappa} - \underline{\kappa}}}_{\substack{>0 \\ \text{By Assumption 1}}} > \sqrt{\theta}
\end{aligned} \tag{46}$$

The last step is to show that when there is a unique equilibrium in switching strategies, then there cannot be any other equilibrium. This argument follows the standard argument of iterated deletion of dominated strategies outlined in Morris and Shin (2000) and is omitted here. □

3.3. Expected welfare of protectionist policy

Given the results from the previous subsection, we know that player i will play abate if their posterior belief ρ_i is such that $\rho_i < \rho_i^*$ and will play not abate if $\rho_i > \rho_i^*$ where ρ_i^* is the value for ρ that solves the following equation:

$$\zeta \exp\left(\rho^* + \frac{1}{2(\sigma_\epsilon + \sigma_z)}\right) - \left[\underline{\kappa} + \Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)(\overline{\kappa} - \underline{\kappa})\right] = 0 \tag{47}$$

From Proposition 1, we know that such a unique ρ_i^* exists given our assumptions. Remember that the posterior belief ρ_i depends on the signal about the true state of the world, x_i, as follows:

$$\rho_i = \frac{\sigma_z \bar{z} + \sigma_\epsilon x_i}{\sigma_z + \sigma_\epsilon} \tag{48}$$

Thus, as we have seen above, the probability that player j attaches to player i playing abate is given by

$$q_i = \text{Prob}(\rho_i < \rho_i^* | \rho_j) = \Phi\left(\sqrt{\theta}\left(\rho_i^* - \bar{z}\right)\right) \tag{49}$$

Similarly, player i attaches the following probability to player j playing abate

$$q_j = \text{Prob}(\rho_j < \rho_j^* | \rho_i) = \Phi\left(\sqrt{\theta}\left(\rho_j^* - \bar{z}\right)\right) \tag{50}$$

Assuming symmetric players, we thus have

$$q_i = q_j = \text{Prob}(\rho < \rho^* | \rho) = \Phi\left(\sqrt{\theta}\left(\rho^* - \bar{z}\right)\right) \tag{51}$$

For the expected welfare of the BTN game, note that the true state of the world pins down all payoffs. More specifically, welfare for the four different outcomes of the game with symmetric players is given by

$$W_{11} = 2\gamma u(2) - 2c - 2\kappa \tag{52}$$

$$W_{10} = 2\gamma u(1) - c - \kappa \tag{53}$$

$$W_{01} = 2\gamma u(1) - c - \kappa \tag{54}$$

$$W_{00} = 2\gamma u(0) \tag{55}$$

where $W_{10} = W_{01}$ in the symmetric game and $\kappa = \zeta \exp(z)$, i.e., the true BTN cost parameter depends on the realization of the state of the world z. Note that W_{00} is equal to the payoffs in the prisoner's dilemma of the pure climate game.

Now, the expected welfare of the climate game with protectionist policy is given by

$$EW = \int_{-\infty}^{\infty} \left[q^2 W_{11} + q(1-q)W_{10} + (1-q)qW_{01} + (1-q)^2 W_{00}\right] f(z)dz \tag{56}$$

where $f(z) = \frac{\sqrt{\sigma_z}}{\sqrt{2\pi}} \exp\left(-\sigma_z \frac{(z-\bar{z})^2}{2}\right)$ is the pdf of the distribution of the state of the world z. Using $\kappa = \zeta \exp(z)$ and $W_{10} = W_{10}$, we can write this integral as

$$\begin{aligned} EW = \int_{-\infty}^{\infty} \Bigg[& \left(\Phi\left(\sqrt{\theta}\left(\rho^* - \bar{z}\right)\right)\right)^2 (2\gamma u(2) - 2c - 2\zeta \exp(z)) \\ & + 2\Phi\left(\sqrt{\theta}\left(\rho^* - \bar{z}\right)\right)\left(1 - \Phi\left(\sqrt{\theta}\left(\rho^* - \bar{z}\right)\right)\right)(2\gamma u(1) - c - \zeta \exp(z)) \\ & + \left(1 - \Phi\left(\sqrt{\theta}\left(\rho^* - \bar{z}\right)\right)\right)^2 2\gamma u(0)\Bigg] \frac{\sqrt{\sigma_z}}{\sqrt{2\pi}} \exp\left(-\frac{\sigma_z(z-\bar{z})^2}{2}\right) dz \end{aligned} \tag{57}$$

This integral can be computed as

$$\begin{aligned} EW = \; & 2\gamma u(0) + 2\left(2\gamma(u(1) - u(0)) - c - \zeta \exp\left(\frac{1}{2\sigma_z} + \bar{z}\right)\right) \Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right) \\ & + 2\gamma\left(u(2) - u(1) - (u(1) - u(0))\right)\left[\Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)\right]^2 \end{aligned} \tag{58}$$

which we can rewrite using $q = \Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)$ to

$$\begin{aligned} EW &= 2\gamma u(0) + 2q\left(2\gamma(u(1) - u(0)) - c - \zeta \exp\left(\frac{1}{2\sigma_z} + \bar{z}\right)\right) + q^2 2\gamma\left(u(2) - u(1) - (u(1) - u(0))\right) \\ &= 2\gamma u(0) + 2q\left[2\gamma(u(1) - u(0)) - c - \mathbb{E}(\kappa)\right] + q^2 2\gamma\left[u(2) - u(1) - (u(1) - u(0))\right] \end{aligned} \tag{59}$$

where $\mathbb{E}(\kappa) = \zeta \exp\left(\frac{1}{2\sigma_z} + \bar{z}\right)$ is the unconditional expected value of κ, i.e., the value before observing any private signals.

Note that the expression for expected welfare can be written more compactly as

$$\begin{aligned} EW &= q^2\left[2\gamma u(2) - 2c - 2\mathbb{E}(\kappa)\right] + 2q(1-q)\left[2\gamma u(1) - c - \mathbb{E}(\kappa)\right] + (1-q)^2\left[2\gamma u(0)\right] \\ &= q^2\mathbb{E}(W_{11}) + 2q(1-q)\mathbb{E}(W_{10}) + (1-q)^2 W_{00} \\ &= W_{00} + q^2\left(\underbrace{\mathbb{E}(W_{11}) - \mathbb{E}(W_{10})}_{\equiv \Delta EW_2} - \underbrace{(\mathbb{E}(W_{10}) - W_{00})}_{\equiv \Delta EW_1}\right) + 2q\underbrace{(\mathbb{E}(W_{10}) - W_{00})}_{\equiv \Delta EW_1} \end{aligned} \tag{60}$$

where W_{00} is the payoff achieved in the pure climate game ('prisoner's dilemma'). Note that $\Delta EW_2 = \overline{\kappa}^w - \mathbb{E}(\kappa)$ and $\Delta EW_1 = \underline{\kappa}^w - \mathbb{E}(\kappa)$ where $\overline{\kappa}^w > \underline{\kappa}^w$, so we can write

$$EW = W_{00} + q\left[2\underline{\kappa}^w + q\left(\overline{\kappa}^w - \underline{\kappa}^w\right) - 2\mathbb{E}(\kappa)\right] \tag{61}$$

$$= W_{00} + 2q\left[q\overline{\kappa}^w + (1-q)\underline{\kappa}^w - \mathbb{E}(\kappa)\right] \tag{62}$$

We thus see that if $\mathbb{E}(\kappa) < \underline{\kappa}^w$, then the BTN game will always be a welfare improvement over the pure climate game. Intuitively, when $\kappa < \underline{\kappa}^w$, then the welfare ordering is $W(1,1) > W(1,0) > W(0,0)$. Thus, even if only one of the two countries abates, such an equilibrium improves welfare compared to the pure climate game.

If $\underline{\kappa}^w < \mathbb{E}(\kappa) < \overline{\kappa}^w$, we see that the welfare effects of the unregulated BTN game are ambiguous. If both countries abate (which happens with probability q^2), then the BTN game is a welfare improvement over the pure climate game. However, if only one of the two countries abates (which happens with probability $2q(1-q)$, then the BTN game leads to a reduction in welfare compared to the pure climate game. The overall effect of the BTN game on ex-ante welfare is thus ambiguous. The risk that only one of the two countries ends up abating is the concern here from a welfare perspective. The lower the probability of that happening, the more likely it is that the unregulated BTN game is in fact a welfare improvement over the pure climate game.

If $\mathbb{E}(\kappa) > \overline{\kappa}^w$, the unregulated BTN game is unambiguously reducing welfare compared to the pure climate game. If $\kappa > \overline{\kappa}^w$, then the welfare ordering is $W(0,0) > W(1,0) > W(1,1)$ and no country should abate from a welfare perspective. The fact that there is a positive probability that one of the two countries (or both) may end up abating destroys expected welfare compared to the prisoner's dilemma of the pure climate game.

4. Welfare Effects of Protectionist Policy

Consider the equilibrium condition given in Proposition 1 by eq. (41).

$$\zeta \exp\left(\rho^* + \frac{1}{2(\sigma_\epsilon + \sigma_z)}\right) = \left[\underline{\kappa} + \Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)(\overline{\kappa} - \underline{\kappa})\right]$$

Let us redefine J as

$$J \equiv \zeta \exp\left(\rho^* + \frac{1}{2(\sigma_\epsilon + \sigma_z)}\right) - \left[\underline{\kappa} + \Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)(\overline{\kappa} - \underline{\kappa})\right] \tag{63}$$

Note that at equilibrium, it holds that $J = 0$. Therefore, we can use implicit function theorem to do comparative statics. That is, for any parameter $\psi = \{\gamma, c, \bar{z}, \sigma_z, \sigma_\epsilon, u(2), u(1), u(0)\}$ of the game we have that

$$\frac{\partial \rho^*}{\partial \psi} = -\frac{\frac{\partial J}{\partial \psi}}{\frac{\partial J}{\partial \rho^*}} \tag{64}$$

Note that given our sufficiency condition for unique equilibrium, we have $\forall \rho \in (\underline{\rho}, \overline{\rho})$

$$\frac{\partial J}{\partial \rho} = \zeta \exp\left(\rho + \frac{1}{2(\sigma_\epsilon + \sigma_z)}\right) - \sqrt{\theta}\phi\left(\sqrt{\theta}(\rho - \bar{z})\right)(\overline{\kappa} - \underline{\kappa}) > 0. \tag{65}$$

Since $\rho^* \in (\underline{\rho}, \overline{\rho})$ this implies,

$$\frac{\partial J}{\partial \rho^*} = \zeta \exp\left(\rho + \frac{1}{2(\sigma_\epsilon + \sigma_z)}\right) - \sqrt{\theta}\phi\left(\sqrt{\theta}(\rho - \bar{z})\right)(\overline{\kappa} - \underline{\kappa}) > 0. \tag{66}$$

Therefore, the relationship between ρ^* and any parameter ψ fully depends on the sign of $-\frac{\partial J}{\partial \psi}$. Further note that since $q^* = \text{Prob}(\rho < \rho^* | \rho^*) = \Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)$, it holds that

$$\frac{\partial q^*}{\partial \psi} = \phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)\frac{\partial \sqrt{\theta}(\rho^* - \bar{z})}{\partial \psi} \tag{67}$$

which implies that q^* and ρ^* move in the same direction in response to parameter changes.

Furthermore, expected welfare of the climate game with protectionist policy is given by eq. (62) as

$$\begin{aligned} EW &= 2\gamma u(0) + 2q\left[2\gamma(u(1) - u(0)) - c - \mathbb{E}(\kappa)\right] + q^2 2\gamma\left[u(2) - u(1) - (u(1) - u(0))\right] \\ &= 2\gamma u(0) + 2q\left[q\kappa^w + (1 - q)\underline{\kappa}^w - \mathbb{E}(\kappa)\right] \end{aligned} \tag{68}$$

where $q = \Phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)$, $\mathbb{E}(\kappa) = \exp\left(\bar{z} + \frac{1}{2\sigma_z}\right)$, and $\underline{\kappa}^w = 2\gamma\left[u(1) - u(0)\right] - c$, $\overline{\kappa}^w = 2\gamma\left[u(2) - u(1)\right] - c$, and $k^w = \frac{1}{2}\underline{\kappa}^w + \overline{\kappa}^w$ as defined in Section 2. This implies that the effect of a change in parameter ψ on expected welfare of the unregulated protectionist climate game is given by

$$\frac{dEW}{d\psi} = \frac{\partial EW}{\partial \psi} + \frac{\partial EW}{\partial q}\frac{\partial q}{\partial \psi} \tag{69}$$

where

$$\frac{\partial EW}{\partial q} = 2\left[2\gamma(u(1)-u(0)) - c - \mathbb{E}(\kappa)\right] + 2q2\gamma\left[u(2)-u(1)-(u(1)-u(0))\right] \tag{70}$$

$$= 2\left[\underline{\kappa}^w + q\left(\overline{\kappa}^w - \underline{\kappa}^w\right) - \mathbb{E}(\kappa)\right] \tag{71}$$

denotes the welfare effect of an increase in abatement probabilities. Note that this welfare effect is negative if the prior belief about κ is sufficiently large:

$$\frac{\partial EW}{\partial q} < 0 \text{ if } \mathbb{E}(\kappa) > \left[q\overline{\kappa}^w + (1-q)\underline{\kappa}^w\right] \tag{72}$$

Given that $\overline{\kappa}^w > \underline{\kappa}^w$, we can thus infer

$$\frac{\partial EW}{\partial q} = \begin{cases} < 0 & \text{if } \mathbb{E}(\kappa) > \overline{\kappa}^w = 2\gamma\left[u(2)-u(1)\right] - c \\ \lesseqgtr 0 & \text{if } \mathbb{E}(\kappa) \in \left(\underline{\kappa}^w, \overline{\kappa}^w\right) \\ > 0 & \text{if } \mathbb{E}(\kappa) < \underline{\kappa}^w = 2\gamma\left[u(1)-u(0)\right] - c \end{cases} \tag{73}$$

Additionally, if abatement through protectionist policy is welfare improving then $\mathbb{E}(\kappa) < q\kappa^w + (1-q)\underline{\kappa}^w < q\overline{\kappa}^w + (1-q)\underline{\kappa}^w$. This implies that if abatement through protectionist policy is welfare improving then $\frac{\partial EW}{\partial q} > 0$. Similarly, if $\frac{\partial EW}{\partial q} < 0$ then it must be the case that protectionism is not welfare improving as, $q\kappa^w + (1-q)\underline{\kappa}^w < q\overline{\kappa}^w + (1-q)\underline{\kappa}^w < \mathbb{E}(\kappa)$.

4.1. Welfare effects of prior belief about BTN cost parameter $\bar{z}$

Now we explore the effect of changes in the mean of the prior distribution about the BTN cost parameter, $\bar{z}$. We have that

$$\begin{aligned} -\frac{\partial J}{\partial \bar{z}} &= -\sqrt{\theta}\phi(\sqrt{\theta}(\rho^* - \bar{z}))(\overline{\kappa} - \underline{\kappa}) < 0 \\ \implies \frac{\partial \rho^*}{\partial \bar{z}} &< 0 \end{aligned} \tag{74}$$

The intuition behind this is that as $\bar{z}$ increases the expected protectionist cost for any country increases. This reduces the incentives for either country to abate for the posterior at ρ^* therefore, both countries lower their cut-off ρ^*.

The total effect of changes in $\bar{z}$ on expected welfare of the BTN climate game is given by

$$\frac{dEW}{d\bar{z}} = \underbrace{\frac{\partial EW}{\partial \bar{z}}}_{<0} + \underbrace{\frac{\partial EW}{\partial q}}_{\lesseqgtr 0} \underbrace{\frac{\partial q}{\partial \bar{z}}}_{<0} \tag{75}$$

where

$$\frac{\partial EW}{\partial \bar{z}} = -2q\frac{\partial \mathbb{E}(\kappa)}{\partial \bar{z}} = -2q\mathbb{E}(\kappa) \tag{76}$$

$$\frac{\partial EW}{\partial q} = 2\left[\underline{\kappa}^w + q\left(\overline{\kappa}^w - \underline{\kappa}^w\right) - \mathbb{E}(\kappa)\right] \lesseqgtr 0 \tag{77}$$

$$\frac{\partial q}{\partial \bar{z}} = \phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)\left[\sqrt{\theta}\underbrace{\frac{\partial \rho^*}{\partial \bar{z}}}_{<0} - \sqrt{\theta}\right] < 0 \tag{78}$$

An increase in $\bar{z}$ directly reduces expected welfare by raising protectionist costs. It also lowers the probability that a country will abate using protectionist policies. If abatement through protectionist measures improves welfare, a reduced likelihood of abatement will diminish expected welfare, as seen in the equation where $\frac{\partial EW}{\partial q} > 0$. However, if protectionism is so costly that increased abatement lowers welfare for sufficiently high prior beliefs about protectionist costs, then a rise in $\bar{z}$ can improve welfare by reducing the probability of abatement. Notably, as $\bar{z} \to \infty$, $q \to 0$, implying that the difference between expected welfare from protectionist policy and no abatement approaches zero.

4.2. Comparative statics of optimal abatement probabilities

Consider the expected welfare from the global game given by

$$EW = 2\gamma u(0) + 2q[q\kappa^w + (1-q)\underline{\kappa}^w - \mathbb{E}(\kappa)]. \tag{79}$$

If a social planner could impose a cut-off strategy on both countries it would set q^w to maximize the expected welfare of the two countries. This value would depend on if the gain from welfare from abating given by κ^w is larger than the expected cost of abating given by $\mathbb{E}(\kappa)$. Specifically,

$$q^w = \begin{cases} 1 & \text{if } \mathbb{E}(\kappa) < \kappa^w \\ 0 & \text{if } \mathbb{E}(\kappa) > \kappa^w \end{cases}. \tag{80}$$

As abatement probability in equilibrium $q^* \in (0,1)$ for real values of $\mathbb{E}(\kappa)$ countries either under-abate or over-abate. As the social planner's first best will always be either full abatement or no abatement we know exactly when countries are over-abating and under-abating for values of κ^w in equilibrium. Specifically, we have the expression for the deviation from the first best is given by

$$D(q^w, q^*) = \|q^w - q^*\| = \begin{cases} 1 - \Phi(\sqrt{\theta}(\rho^* - \bar{z})) & \text{if } \mathbb{E}(\kappa) < \kappa^w \\ \Phi(\sqrt{\theta}(\rho^* - \bar{z})) & \text{if } \mathbb{E}(\kappa) > \kappa^w \end{cases} \tag{81}$$

Equation (79) also gives us the minimum probability, q^P of abatement required in order for second-best protectionism to be welfare-improving than having no abatement at all. Specifically,

$$q^P = \begin{cases} 0 & \text{if } \mathbb{E}(\kappa) < \underline{\kappa}^w \\ \frac{\mathbb{E}(\kappa) - \underline{\kappa}^w}{\kappa^w - \underline{\kappa}^w} & \text{if } \mathbb{E}(\kappa) \in [\underline{\kappa}^w, \kappa^w] \\ 1 & \text{if } \mathbb{E}(\kappa) > \kappa^w \end{cases} \tag{82}$$

Crucially, if $q^P < q^*$, then the second-best policy is to let countries do their abatement themselves with the gains of protectionism. If $q^P > q^*$, then the second-best policy is to let no abatement occur as protectionism is too costly. Note that in the range $\mathbb{E}(\kappa) \in [\underline{\kappa}^w, \kappa^w]$ some level of under-abatement can be tolerated for the second-best policy to have countries choose their likelihood of abatement themselves.

With regard to the effect of the prior mean $\bar{z}$ on optimal abatement probabilities, note that

$$q^w = \begin{cases} 1 & \text{if } \bar{z} < \bar{z}^w \\ 0 & \text{if } \bar{z} > \bar{z}^w \end{cases} \tag{83}$$

where $\bar{z}^w$ solves $\mathbb{E}(\kappa) = \kappa^w$. Further,

$$D(q^w, q^*) = \|q^w - q^*\| = \begin{cases} 1 - \Phi(\sqrt{\theta}(\rho^* - \bar{z})) & \text{if } \bar{z} < \bar{z}^w \\ \Phi(\sqrt{\theta}(\rho^* - \bar{z})) & \text{if } \bar{z} > \bar{z}^w \end{cases} \tag{84}$$

and

$$q^P = \begin{cases} 0 & \text{if } \bar{z} < \bar{z}' \\ \frac{\mathbb{E}(\kappa)-\underline{\kappa}^w}{\kappa^w-\underline{\kappa}^w} & \text{if } \bar{z} \in [\bar{z}', \bar{z}^w] \\ 1 & \text{if } \bar{z} > \bar{z}^w \end{cases} \tag{85}$$

where $\bar{z}'$ solves $\mathbb{E}(\kappa) = \underline{\kappa}^w$ with $\mathbb{E}(\kappa) = \zeta \exp\left(\bar{z} + \frac{1}{2\sigma_z}\right)$ so that $\frac{\partial q^P}{\partial \bar{z}} \geq 0$.

Note that the expression of under-abate in eq. (84) goes to 0 if $\bar{z} \to -\infty$ or if $\bar{z} \to \infty$. It is only at the intermediate value of $\bar{z}$ for which under-abatement (or over-abatement) grows. Specifically,

$$\frac{\partial D}{\partial \bar{z}} = \begin{cases} -\frac{\partial q^*}{\partial \bar{z}} > 0 & \text{if } \bar{z} < \bar{z}^w \\ \frac{\partial q^*}{\partial \bar{z}} < 0 & \text{if } \bar{z} > \bar{z}^w \end{cases} \tag{86}$$

As D is increasing in $\bar{z}$ for $\kappa^w > \mathbb{E}(\kappa)$ and decreasing in $\bar{z}$ for $\kappa^w < \mathbb{E}(\kappa)$ and D has maximum value when $\kappa^w = \mathbb{E}(\kappa)$. Let q_D^* be the equilibrium probability of abatement of countries when $\kappa^w = \mathbb{E}(\kappa)$. The maximized value of the equilibrium response for the first best is given by $D_{max} = \max\{1 - q_D^*, q_D^*\}$.

Further, q^P is an increasing function of $\bar{z}$ as when expected protectionism costs go up the likelihood of abatement must also go up to ensure the gains of abatement outsize the costs. Since q^* is a decreasing function of $\bar{z}$ also bounded between 0 and 1, it must be the case that there exists some $\bar{z}''$ such that

$$q^* - q^P = \begin{cases} q^* - q^P > 0 & \text{if } \bar{z} < \bar{z}'' \\ q^* - q^P < 0 & \text{if } \bar{z} > \bar{z}'' \end{cases}. \tag{87}$$

This $\bar{z}''$ solves the equation,

$$q^* \kappa^w + (1 - q^*)\underline{\kappa}^w = \zeta \exp\left(\bar{z}'' + \frac{1}{2\sigma_z}\right) \equiv \mathbb{E}(\kappa''). \tag{88}$$

Note that $\mathbb{E}(\kappa'') < \kappa^w$, therefore, for all values of $\bar{z} \in [\bar{z}'', \bar{z}^w]$, where $\bar{z}^w$ solves $\mathbb{E}(\kappa) = \kappa^w$, countries are under-abating. This means that for low enough values of $\bar{z}$ allowing for protectionism is the second best policy as there are enough expected gains to abatement to overcome the costs of protectionism. However, for $\bar{z} \in [\bar{z}'', \bar{z}^w]$, protectionism costs are too high that countries under-abate too much and it is second best for countries to

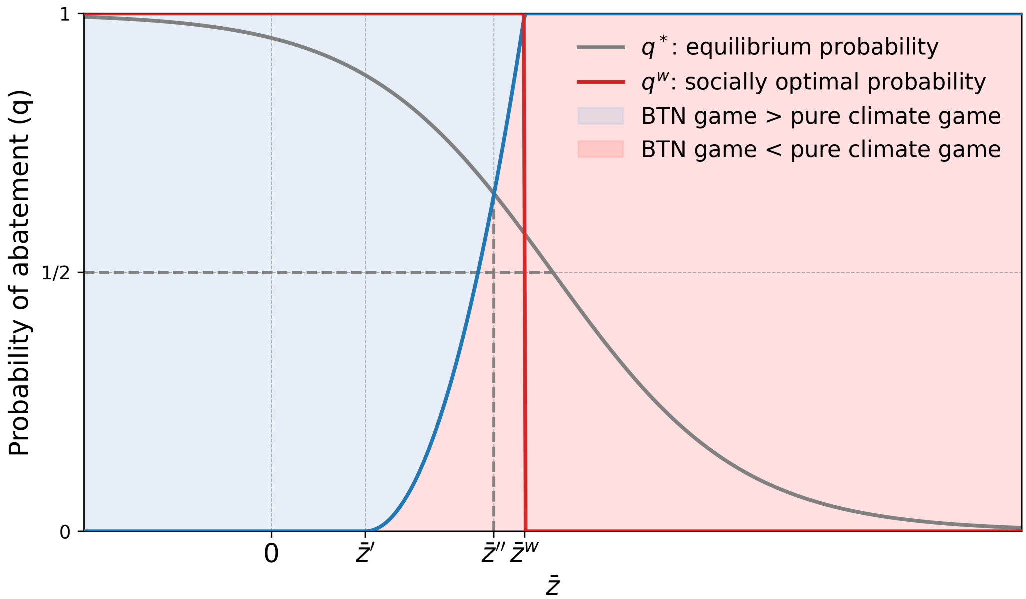

FIGURE 3. Welfare Effects of $\bar{z}$ (Mean of Prior Belief about BTN costs κ)

Notes: The figure illustrates the welfare effects of $\bar{z}$, the mean of prior beliefs about the costs associated with BTN policies. $\bar{z}'$ solves $\mathbb{E}(\kappa) = \underline{\kappa}^w$, $\bar{z}''$ solves $\mathbb{E}(\kappa) = q^*\kappa^w + (1 - q^*)\underline{\kappa}^w$, and $\bar{z}^w$ solves $\mathbb{E}(\kappa) = \kappa^w$. The welfare rankings of payoffs are such that $W(1,1) > W(1,0) > W(0,0)$ if $\bar{z} < \bar{z}'$, $W(1,1) > W(0,0) > W(1,0)$ if $\bar{z}' < \bar{z} < \bar{z}^w$, and $W(0,0) > W(1,1)$ if $\bar{z} > \bar{z}^w$. The blue line represents q^P, the minimum abatement probability for the BTN game to potentially be a welfare improvement over the pure climate game, and solves $q^P\kappa^w + (1 - q^P)\underline{\kappa}^w = \mathbb{E}(\kappa)$.

remain in prisoners' dilemma and not abate at all. For $\bar{z} > \bar{z}^w$, countries are over-abating as the gains from abatement will never be as much as the expected protectionist costs so the second-best policy is to stay in prisoners' dilemma and never abate.

Summing up, equilibrium abatement probabilities in the BTN game align with socially optimal probabilities for very low or very large values of $\bar{z}$. The distance between socially optimal and equilibrium abatement probabilities is largest for intermediate values of $\bar{z}$. Intuitively, very low values of $\bar{z}$ lead to near-certain abatement, which is efficient. On the other hand, very high values of $\bar{z}$ lead to an effectively zero probability of abatement, which is efficient as well. Intermediate values of $\bar{z}$ lead to abatement probabilities larger than socially optimal. Figure 3 illustrates.

If $\bar{z} < \bar{z}^w$, abatement by both countries is constrained efficient in the BTN climate game since $W_{11} > W_{00}$. If $\bar{z} < \bar{z}' < \bar{z}^w$, the welfare ranking of the payoffs is $W_{11} > W_{10} > W_{00}$. This means that expected BTN costs are low enough for the BTN game to deliver a welfare benefit over the pure climate game (where no country abates), even if only one country abates. As a result, any probability of abatement in the BTN game will lead to a welfare improvement over the pure climate game.

For $\bar{z} \in \left(\bar{z}', \bar{z}^w\right)$, the welfare ranking shifts to $W_{11} > W_{00} > W_{10}$. Here, the expected BTN costs are higher, so the BTN climate game only generates a welfare benefit over the pure climate game if both countries abate. Consequently, the equilibrium abatement probability must be large enough to offset the risk of only one country abating, which would otherwise result in welfare loss. As $\bar{z}$ increases, the welfare damage from unilateral abatement rises, requiring even larger equilibrium abatement probabilities for the BTN climate game to improve welfare over the pure climate game. Once $\bar{z} > \bar{z}''$, equilibrium abatement probabilities are no longer sufficient to compensate for the risk of one country abating, and the BTN game becomes welfare-damaging compared to the pure climate game.

When $\bar{z}$ exceeds $\bar{z}^w$, abatement is no longer optimal in the BTN game (since $W_{00} > W_{11}$), and any non-zero equilibrium abatement probability will reduce welfare compared to the pure climate game. As equilibrium abatement probabilities approach zero for large $\bar{z}$, the expected payoff of the BTN climate game aligns with that of the pure climate game. The greatest disparity between socially optimal and equilibrium abatement probabilities occurs near $\bar{z}^w$, where socially optimal probabilities abruptly shift from 1 to 0, while equilibrium probabilities decrease gradually.

4.3. Optimal Policy

Suppose that there is a regulating authority in place, such as the WTO, that can choose both countries' abatement level $\alpha_R \in [0, 1]$.

Expected welfare in the regulated BTN climate game is given by

$$EW = 2\gamma u(0) + 2q\left[2\gamma(u(1) - u(0)) - c - \alpha_R \mathbb{E}(\kappa)\right] + q^2 2\gamma\left[u(2) - u(1) - (u(1) - u(0))\right] \tag{89}$$

$$= W_{00} + 2q\left[q\kappa^w + (1-q)\underline{\kappa}^w - \alpha_R \mathbb{E}(\kappa)\right] \tag{90}$$

The marginal effect of regulation α_R on expected welfare is given by

$$\frac{dEW}{d\alpha_R} = \underbrace{\frac{\partial EW}{\partial \alpha_R}}_{<0} + \underbrace{\frac{\partial EW}{\partial q}}_{\lesseqgtr 0}\underbrace{\frac{\partial q}{\partial \alpha_R}}_{>0} \tag{91}$$

where

$$\frac{\partial EW}{\partial \alpha_R} = -2q\mathbb{E}(\kappa) < 0 \tag{92}$$

$$\frac{\partial EW}{\partial q} = 2\left[\underline{\kappa}^w + q\left(\overline{\kappa}^w - \underline{\kappa}^w\right) - \alpha\mathbb{E}(\kappa)\right] \lesseqgtr 0 \tag{93}$$

$$\frac{\partial q}{\partial \alpha_R} = \phi\left(\sqrt{\theta}(\rho^* - \bar{z})\right)\sqrt{\theta}\underbrace{\frac{\partial \rho^*}{\partial \alpha_R}}_{>0} > 0 \tag{94}$$

Intuitively, more protectionism increases the probability that countries will play abatement ($\partial q/\partial \alpha_R > 0$), which increases welfare as long as ($\partial EW/\partial q > 0$). At the same time, more protectionism increases BTN waste ($\partial EW/\partial q > 0$), which decreases the value of more protectionism.

The following Proposition shows that regulation can improve the outcome of the BTN climate game and the pure climate game as long as the expected BTN costs $\mathbb{E}(\kappa)$ are not too large.

PROPOSITION 2. *If* $\mathbb{E}(\kappa) < \frac{\underline{\kappa}^w}{\gamma(u(1)-u(0))-\underline{\kappa}^w}$, *then optimal protectionist policy* α_R^* *is positive.*

PROOF. Note that if $\alpha_R < c - \gamma(u(1) - u(0))$, then not abating is the dominant strategy for both countries. For a positive α^R to be welfare maximizing, the expected utility for both countries should be better than the combined payoff they would get if they both choose not to abate, $W_{00} = 2\gamma u(0)$, which is the payoff of the pure climate game. By rearranging our expected welfare and comparing it with W_{00}, we get

$$\mathbb{E}(W) - W_{00} = 2q\left[q\kappa^w + (1-q)\underline{\kappa}^w - \alpha_R\mathbb{E}(\kappa)\right] \tag{95}$$

Note that if $\underline{\kappa}^w - \alpha_R\mathbb{E}(\kappa) > 0$ and $\kappa^w - \alpha_R\mathbb{E}(\kappa) > 0$ and if q is positive, then $\mathbb{E}(W)$ is greater than W_{00}. Now we know that $\kappa^w > \underline{\kappa}^w$. Thus, if $\underline{\kappa}^w > \alpha_R\mathbb{E}(\kappa)$, then $\kappa^w > \alpha_R\mathbb{E}(\kappa)$.

Since the lower bound of α_R is $c - \gamma(u(1) - u(0))$ for q to be positive, a sufficient condition for the existence of a positive optimal α_R^* is,

$$\underline{\kappa}^w > [c - \gamma(u(1) - u(0))]\mathbb{E}(\kappa) \tag{96}$$

$$\implies \mathbb{E}(\kappa) < \frac{\underline{\kappa}^w}{c - \gamma(u(1) - u(0))} = \frac{\underline{\kappa}^w}{\gamma(u(1) - u(0)) - \underline{\kappa}^w} = \frac{\underline{\kappa}^w}{1 - \underline{\kappa}}. \tag{97}$$

Note, that this condition does not guarantee that the optimal α_R^* will produce a unique equilibrium, it only guarantees that there exists an $\alpha_R > 0$ that could improve welfare from $\alpha_R = 0$. From eq. (95) it follows that α_R is also finite. Note, we have the expected welfare gain from inducing abatement given by the expression

$$\mathbb{E}(W) - W_{00} = 2q\left[(1-q)\underline{\kappa}^w + q\kappa^w - \alpha_R\mathbb{E}(\kappa)\right]. \tag{98}$$

where $\underline{\kappa}^w$ is the gain from only one country abating, κ^w is the gain from both countries abating, and $\alpha_R\mathbb{E}(\kappa)$ is the BTN waste from abating using protectionist policies. If at $\alpha_R = 1$ the expression above is positive, then full protectionist climate policy welfare dominates the prisoners' dilemma equilibrium. □

5. Conclusion

This paper explores the welfare effects of protectionist climate policies in the context of the green transition. While economists have traditionally cautioned against protectionism due to its distortive effects, we demonstrate that, in the case of climate policies, these distortions can have strategic value by encouraging coordination between countries on climate action. We emphasize the nuanced role that protectionist policies can play in the green transition, noting that the World Trade Organization's blanket restrictions on trade-distorting industrial policies may, in certain cases, undermine global welfare. In a second-best world, allowing limited protectionist measures could help overcome the coordination failures that often plague international climate agreements.

Our findings highlight the importance of tailoring international regulations to the specific characteristics of green industrial policies. When expected distortions are low, protectionist policies may enhance welfare by promoting climate cooperation. When expected protectionist costs are high, the welfare impact is less of a concern, as countries will avoid pursuing such policies due to their prohibitive costs. However, when distortions from protectionist green policies are expected to be moderate, the risks of coordination failure outweigh the potential benefits, and stricter regulatory oversight may be necessary. Going forward, policy frameworks should consider these trade-offs carefully to strike a balance between encouraging climate action and minimizing the negative consequences of protectionism.

In future work, we plan to make the BTN climate game dynamic, allowing us to study the effects of delays in the green transition and how countries learn from realized BTN costs in the first period of the game. We will also explore the role of country heterogeneity and its impact on the welfare effects of the BTN climate game.

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