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Dear selection committee,

I am a Ph.D. candidate in Applied Economics at HEC Montréal, under the supervision of Professors Justin Leroux (HEC Montréal), Justin Caron (HEC Montréal) and Étienne Billette de Villemeur (Université de Lille). I am writing to express my interest in the PhD Student Workshop on Climate Finance. My doctoral research agenda investigates the design of Carbon Contracts for Difference (*CCfDs*) as a mechanism to stimulate low-carbon investment under political uncertainty, focusing on their ability to balance commitment credibility, economic efficiency, and democratic flexibility. I expect to complete my Ph.D. in 2027.

In my current work, I develop a dynamic theoretical model in which political turnover risks undermine the credibility of future climate policy, creating a hold-up problem that discourages firms from investing in capital-intensive abatement technologies. *CCfDs*, by guaranteeing a minimum carbon price, can mitigate this under-investment and replicate the full-commitment investment benchmark under certain conditions. However, my findings highlight asymmetric distortions: when the initiating government loses office, *CCfDs* can induce overproduction and excess emissions; when it remains in office, they may induce underproduction. This "political rebound effect" reveals a subtle tension between stabilizing investment incentives and maintaining efficient emissions trajectories.

Beyond the efficiency dimension, my research also examines the institutional and political economy implications of *CCfDs*, by locking in fiscal commitments that outlast electoral cycles, *CCfDs* can enhance the credibility of climate policy but may reduce future governments' flexibility to adapt to new information or shifting public preferences. This creates a normative trade-off between democratic responsiveness and democratic continuity, one that has been largely overlooked in the current literature. In my forthcoming work, I wish to extend this framework by

exploring CCfD designs with output caps, contingent renegotiation clauses, and optimal strike price calibration to reduce rebound effects without eroding credibility.

Going forward, I plan to integrate empirical analysis into my research by studying existing and proposed *CCfD* schemes in Europe and Canada, and to investigate how contract structure interacts with electoral cycles, market dynamics, and technology cost curves. More broadly, my agenda lies at the intersection of environmental economics, mechanism design, and political economy, seeking to design decarbonization policies that remain both economically robust and democratically legitimate.

Professor Justin Leroux (justin.leroux@hec.ca) would be pleased to serve as a reference for my application. I would be delighted to provide any further information and look forward to the opportunity to contribute to the climate finance community.

Sincerely,
Nicolas Pinsonneault
Ph.D. Candidate, Department of Applied Economics
HEC Montréal

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Professional Experience

Polytechnique Montréal
Lecturer *2023 - Present*
Economic Issues of Sustainable Development in Engineering (IND8110)

HEC Montréal
Research Assistant *2021 - 2023*
- Climate risk and Mortgage-Backed Securities (MBS)
- Economic analyses of U.S. mortgage lending
- Political economy of climate change

HEC Montréal
Teaching Assistant *2020 - 2023*
- Macroeconomic and microeconomic analysis (BBA, M.Sc)
- Economic behavior and project evaluation (MBA)

Intact Insurance
Claims Department *2019 - 2020*

Education

HEC Montréal
Ph.D. in Applied Economics *2022 - Present*
Supervisors: Justin Caron, Justin Leroux, Étienne Billette de Villemeur

HEC Montréal
M.Sc. in Applied Economics *2020 - 2022*

HEC Montréal
BBA in Applied Economics *2017 - 2020*
With Honors

EBS Universität
Exchange Program *2019*
German language training (A1, A2, B1)

Research Interests

- Environmental economics
- Political economy
- Contract theory

Ongoing Projects

"Political Turnover and the Design of Carbon Contracts for Difference"

"Sustaining Our Public Services: Insights from a Quebec Municipal Outreach Tour on Sustainable

Water Services Financing" (with Justin Leroux)

Scholarships

2024: Hydro-Québec Excellence Scholarship (Ph.D) ($20,000)
2022: Trottier Scholarships – Trottier Energy Institute ($51,000 over three years)
2022: Daniel-Brosseau and Peter-Letko Admission Scholarship (Ph.D) (25,000$)
2021: Hydro-Québec Excellence Scholarship ($10,000)
2020: Research Grant – Tradable Climate Liabilities ($5,000)
2019: BBA Excellence Scholarship ($3,000)

Awards and Distinctions

2025: Réseau Environnement - Irma Levasseur Distinction - Emerging Professional
2022: Finalist – 2022 Essay Competition, John Locke Institute, Oxford University
Essay titled: Revisiting Georgism: A Discussion on Spatial Fairness, Redistribution and Taxation
2021: Finalist – 8th University Essay Competition – IAPC
Essay titled: Pandemic, Permafrost and Policy (with Sidita Belo)

Computer Skills

Programming: R, Python, PostgreSQL, LaTeX
GIS: ArcGIS, QGIS

Languages

French: Native
English: Fluent
German: Intermediate (B1)

Other Professional Qualifications

Diving: PADI Instructor (OWSI)

Political Turnover and the Design of Carbon Contracts for Differences

Nicolas Pinsonneault[†]

[†] *Department of Applied Economics, HEC Montréal* *

Abstract

We study how incumbent governments can induce clean investment in the face of political turnover. In a dynamic model with uncertain future climate policy, we show that Contracts for Carbon Differences (*CCfDs*) mitigate underinvestment by guaranteeing a fixed carbon price to firms. When commitments are credible across political administrations, *CCfDs* can replicate the full-commitment investment benchmark. However, political uncertainty creates asymmetric distortions: governments that lose office face over-production and excess emissions, while re-elected incumbents may induce underproduction. Our results reveal a tradeoff between investment credibility and democratic flexibility, with implications for the design of long-term climate policy.

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1 Introduction

Climate policy, especially carbon taxes, is a key instrument in global efforts to combat climate change by putting a price on carbon emissions. As of today, numerous countries have implemented various forms of carbon pricing, although the scope, structure, and effectiveness of these policies vary significantly across regions (Postic and Fetet (2020)). Politically, the adoption and sustainability of carbon taxes are fraught with unpredictability. Policymaking, among other things, is subject to electoral cycles (Harstad (2020)), lobbying by interest groups (Kalkuhl et al. (2020)), and shifts in public opinion (Ewald et al. (2022)). These factors can result in abrupt policy reversals or diluted tax implementations, undermining their potential impact. As Brunner et al. (2012) put it, from a public choice perspective, the government consists of changing individuals with evolving preferences. Different stakeholders, with conflicting interests, strive to shape policies to their benefit. For example, current officeholders might lower the carbon price to boost economic growth before elections to gain votes. Policy risk also arises from shifting political majorities, leading to alternating special interests being represented (Strausz (2009)). Consequently, carbon policy can vary significantly depending on the ruling political party, influenced by their ideologies and constituencies. For instance, political resistance has led to the rollback or weakening of carbon tax policies in various jurisdictions, reflecting the contentious nature of such measures. A notable example of political resistance leading to the rollback of carbon tax policies is the case of Australia. In 2012, the Australian government, led by the Labor Party under Prime Minister Julia Gillard, introduced a carbon pricing mechanism stemming from the 2011 *Clean Energy Act*. Shortly after, Liberal-National Coalition, led by Tony Abbott, won the 2013 general election. True to his campaign promise, the Abbott government repealed the carbon tax in 2014, just two years after its implementation.

Central to these issues is the problem of time-inconsistency. In their seminal pa-

per, Kydland and Prescott (1977) famously mentioned that "economic planning is not a game against nature but, rather, a game against rational economic agents". The essence of the time consistency problem is that a policy considered optimal by economic policymakers initially, when it can shape the expectations of households and firms, often ends up not being implemented later, once those expectations have already influenced private behavior. Consequently, policymakers tend to revise their decisions. This phenomenon often results from the differing timelines of political cycles and the slow, cumulative nature of environmental impacts. While politicians may prioritize policies that yield immediate benefits to secure re-election or public approval, the long-term nature of climate change requires sustained and consistent efforts over decades. Consequently, this misalignment can lead to insufficient or inconsistent policy measures, undermining the overall effectiveness of climate action and most importantly, create a hold-up problem (Williamson (1975)), where firms under-invest as they fear being stuck with stranded assets (Kalkuhl et al. (2020)). Not too distant from the notion of time-inconsistency, is the incomplete contracts literature and more precisely, the aforementioned hold-up problem. This occurs when investors cannot guarantee themselves a sufficient share of the return through *ex-post* bargaining, say with the regulator.

Solutions that have been explored include establishing independent climate institutions (Helm et al. (2003)), setting legally binding emission targets, and integrating climate goals into broader economic planning, such as making contingent trade agreements (Harstad (2024)) or targeting investment subsidies into sectors that are complementary to future green investment possibilities (Harstad (2020)). One approach to mitigating policy risk is the use of Carbon Contracts for Difference (*CCfDs*). These financial instruments function as a commitment device by ensuring that firms receive compensation if the actual carbon price falls below a pre-agreed strike price. Conversely, if the market carbon price exceeds the strike price, firms return the excess to

the government. *CCfDs* thus serve to stabilize expectations and de-risk investments in low-carbon technologies, providing a mechanism through which governments can credibly commit to climate policy goals even in the face of political turnover (**?**). While contracts for difference have been deployed in some jurisdictions, such as in renewable electricity markets (May et al. (2018)), their broader implications regarding policy continuity, investment behavior, and democratic governance remain underexplored.

This paper contributes to the literature by examining the role of *CCfDs* in addressing the hold-up problem and improving policy implementation in the presence of political uncertainty. We develop a theoretical framework that models firm behavior under policy uncertainty and demonstrate how *CCfDs*, under strict conditions, can act as an implementation device that can enable a desired investment outcome. We show that CCfDs can provide firms with a level of certainty that traditional carbon pricing mechanisms fail to achieve. However, while *CCfDs* can enhance policy credibility and reduce uncertainty for firms, they do not necessarily implement the desired *ex-ante* level of production or emissions reductions. Since *CCfDs* provide a subsidy-like effect by stabilizing carbon prices, they may encourage firms to increase their output beyond what would be socially optimal under a fully credible carbon pricing regime. This can trigger a rebound effect, where the increased production partially offsets the intended environmental benefits of the policy. In particular, if the *CCfD* strike price is set too high, firms might overproduce and emit more than they would under a well-functioning and predictable carbon tax, highlighting a fundamental limitation of *CCfDs* in fully aligning private incentives with the social cost of carbon.

The remainder of this paper is structured as follows. Section 2 situates our analysis within the broader literature on political commitment, time inconsistency, and

climate policy uncertainty. Section 3 develops the theoretical model, highlighting the investment decisions of firms in the face of uncertain future carbon taxes. Section 4 introduces *CCfDs* as an implementation device and examines their effectiveness in different political environments, Section 5 discusses broader implications, including potential trade-offs between policy credibility and democratic flexibility. Finally, we conclude with policy recommendations and directions for future research.

2 Relation to the literature

2.1 Commitment, political cycles and time inconsistency

Commitment in economics refers to the ability of policymakers to make credible promises about future policies. The importance of commitment has been highlighted in numerous studies, most famously including Kydland and Prescott (1977). They argue that policymakers, if left unchecked, may have incentives to deviate from previously announced policies to achieve short-term objectives, leading to suboptimal long-term outcomes. Rules ensure predictability and prevent policymakers from changing course based on short-term incentives, which can lead to time inconsistency. This problem is particularly pronounced in monetary and fiscal policies, where governments may renege on commitments to low inflation or sustainable debt levels.

One proposed solution to the commitment problem is the establishment of independent institutions, such as central banks, which can credibly commit to policy objectives without political interference (Rogoff (1985)).By insulating decision-making from short-term political pressures, these institutions enhance policy credibility and reduce uncertainty for economic agents. Similarly, fiscal rules and legally binding policy frameworks have been implemented in various countries to reinforce commitment to long-term objectives (Alesina and Perotti (1996)). The interaction between commitment and political cycles has significant implications for investment and long-term

economic growth. When governments lack credibility, firms and investors face uncertainty about future policies, leading to suboptimal investment decisions. Alesina and Tabellini (1990) argue that short-term political pressures may lead to suboptimal public investment decisions, where governments prioritize projects with immediate electoral benefits rather than those that enhance long-term productivity. This dynamic can distort capital allocation, leading to inefficiencies in infrastructure and public services that are crucial for sustained economic growth. Additionally, firms operating in environments with high political risk tend to adopt more conservative investment strategies, preferring shorter payback periods and lower capital commitments (Gulen and Ion (2016)).This conservative approach can hinder innovation and long-term technological advancements, further affecting national competitiveness. In response, Harstad (2020) argues that strategically designed investment subsidies can mitigate this problem by directing support toward technologies that facilitate further decarbonization over time. Such subsidies target sectors that are complementary to future low-carbon investments, ensuring that initial commitments lead to sustained emissions reductions.

2.2 Incomplete contracts and implementation

The central idea within implementation theory is to design rules or mechanisms that ensure a particular social choice function (a rule mapping preferences to outcomes) is implementable, meaning it arises as the equilibrium outcome of a game induced by the mechanism. A core challenge lies in reconciling incentive compatibility with the broader goals of efficiency, equity, or welfare maximization. Implementation theory examines how economic policies or mechanisms can be designed to achieve desired outcomes despite strategic behavior by agents. Originally developed within mechanism design (Maskin (1999)), implementation theory has been widely applied in public economics, contract theory, and institutional design.

A key insight from implementation theory is that policies must be incentive-compatible to ensure compliance. Governments face challenges in designing mechanisms that align private incentives with socially optimal outcomes, especially when there is asymmetric information or strategic manipulation (Moore and Repullo (1988)). For example, in public-private partnerships, incomplete contracts may lead to renegotiation that benefit politically connected firms rather than optimizing efficiency (Tirole (1999)). From an investment perspective, implementation theory suggests that governments should design self-enforcing agreements that remain robust to political and economic fluctuations. One approach is the use of commitment devices, such as independent regulatory agencies or automatic stabilizers, which reduce the discretionary power of policymakers and enhance credibility (Acemoglu (2003)).

In the context of climate policy, and central to our paper, implementation theory supports the design of mechanisms such as *Carbon Contracts for Difference*, where governments commit to predetermined carbon pricing structures, reducing uncertainty for investors in low-carbon technologies.

2.3 Carbon contracts for difference

Carbon Contracts for Difference (*CCfDs*) are financial instruments designed to incentivize investment in low-carbon technologies by mitigating risks associated with carbon pricing and in some cases, with market uncertainties[1]. *CCfD* payments are triggered when the effective carbon price differs from a previously determined strike price. Note that if the carbon price falls below the strike, the firm gets compensated for the difference. If the carbon price rises above the strike, the payment burden is reversed and the firm pays the government. *CCfDs* are particularly useful for capital-intensive technologies like green hydrogen production, carbon capture and

[1]This is notably the case in Germany, where *CCfDs* also cover the difference in CAPEX and OPEX of cleaner processes, compared to a less climate-friendly benchmark, see (Federal Ministry for Economic Affairs and Climate Action (BMWK) (2022))

storage (CCS), and advanced renewable energy systems, where high upfront costs and long payback periods often deter private investment (**?**).

Carbon Contracts for difference have recently gained traction in the literature. Notably, previous work has highlighted the importance of contract design, emphasizing strike prices and durations that balance investor (firms) incentives with government cost-effectiveness, as explored by **?**. However, while *CCfDs* offer significant benefits, their design must balance government expenditure with efficiency concerns. Setting the strike price too high could lead to excessive government payouts, while setting it too low may fail to incentivize sufficient investment. Moreover, *CCfDs* do not directly impose emissions caps, meaning that without complementary policies, they could inadvertently lead to increased overall production and emissions—a phenomenon known as the rebound effect.

This paper builds on these insights by examining how *CCfDs* function as an implementation device in the face of political uncertainty. While they reduce investment risk for firms, their effectiveness in fully aligning private incentives with long-term welfare goals remains an open question and our conclusions show that one must be cautious when designing such contracts. The next sections explores this issue in greater depth by developing a theoretical framework that captures the interaction between policy credibility, firm behavior, and implementation constraints.

3 The Hold-up problem under uncertainty

3.1 The timing of the game

Consider a simple biparty setting. Let τ^I be the incumbent government's optimal tax, which is equal to its perceived social cost of carbon and assume that firms base their abatement decisions (e) - which will come into effect in the next period - on their

expectations of the future tax rate, rather than solely on the current government's policy announcement. This creates a commitment problem, as political uncertainty implies that τ may differ from τ^I if the challenger party is elected in period 2. Concretely, this means that the incumbent government doesn't have full control regarding the firm's carbon intensity decision in period 1 to be effective in period 2; where it may, or may not, remain in power.

The sequence of decisions is as follows:

1. **Period 1:**
    - The incumbent government announces a tax τ^I equal to its perceived social cost of carbon and to be effective in the next period.
    - Firms invest in abatement technology e, based on their expectation of the future economic environment, which is in part dictated by expected tax $\mathbb{E}[\tau] = \lambda\tau^I + (1-\lambda)\tau^C$, where λ denotes the instantaneous probability that the incumbent is reappointed and where τ^C is the challenger's announced policy.
2. **Period 2:**
    - If the period 1 government is reappointed, $\tau = \tau^I$ is implemented, otherwise $\tau = \tau^C$
    - Firms produce quantities $q(e, \tau)$

3.2 The firm's problem

The representative price-taking firm operates in a market with downward-sloping demand, characterized by $D'(p) < 0$, where p is the global market price for the good. We make the simplification that the firm is a price taker and that it operates in an international setting such that it can't transfer the carbon-tax burden to consumers

in the short-run. The firm faces uncertainty regarding the effective carbon tax τ that will be realized in the next period but must decide on its emission intensity e before elections happen and accordingly, before the period 2 tax is realized. The firm's emission intensity e can be reduced through costly investment, with the cost function $K(e)$ satisfying $K'(e) < 0$ and $K''(e) > 0$, reflecting decreasing marginal returns to abatement investment.

In period 2, after observing the realized tax $\tau \in \{\tau^I, \tau^C\}$, the firm chooses its production level q, with production costs defined by $C'(q) > 0$ and $C''(q) > 0$, to maximize its profit. The problem is solved by backward induction: starting from the firm's optimal production choice in period 2 and then determining its investment in abatement at time 1. The firm's optimization problem can thus be written as:

$$\max_e \mathbb{E}[\pi] = \mathbb{E}\left[\underbrace{\max_q \left(pq - e\tau q - C(q)\right)}_{\text{period 2}} - K(e)\right] \tag{1}$$

where in a biparty setting, the first period's problem becomes

$$\begin{aligned}\max_e \mathbb{E}[\pi] = {} & \lambda\left[pq^I(e,\tau^I) - eq^I(e,\tau^I)\tau^I - C(q^I(e,\tau^I))\right] \\ & + (1-\lambda)\left[pq^C(e,\tau^C) - eq^C(e,\tau^C)\tau^C - C(q^C(e,\tau^C))\right] - K(e)\end{aligned} \tag{2}$$

Solving by backward induction, we get the second-period first order condition with respect to q

$$p - \tau \cdot e(\lambda, \tau^I, \tau^C) = \frac{\partial C(q)}{\partial q} \tag{3}$$

Which states that the marginal benefit of producing more, which is the sales price minus the tax payments, is equal to the marginal cost of production. In expectations,

this becomes

$$\mathbb{E}\left[p - \tau \cdot e(\lambda, \tau^I, \tau^C) - \frac{\partial C(q)}{\partial q}\right] = 0$$
$$\lambda\left[p - \tau^I e(\lambda, \tau^I, \tau^C) - \frac{\partial C(q^I)}{\partial q}\right] + (1-\lambda)\left[p - \tau^C e(\lambda, \tau^I, \tau^C)\frac{\partial C(q^C)}{\partial q}\right] = 0$$

rearranging

$$\lambda\left[p - \tau^I e(\lambda, \tau^I, \tau^C)\right] + (1-\lambda)\left[p - \tau^I e(\lambda, \tau^C, \tau^C)\right] = \lambda\frac{\partial C(q^I)}{\partial q} + (1-\lambda)\frac{\partial C(q^C)}{\partial q} \tag{4}$$

Where the expected period 2 output under uncertainty $q^u(e, \lambda, \tau^I, \tau^C)$ is the solution to (4) and is determined by both parties' announced tax rates as well as by the probability that the incumbent remains in power. We make the assumption that there is no *ex-ante* uncertainty regarding the shape of the production cost function $C(q)$ in period 2. Going back to the period 1 problem to solve for the choice of emission intensity, we compute the first-order condition with respect to e.

$$\lambda\left[p\frac{\partial q^I(e,\tau^I)}{\partial e} - \tau^I q^I(e,\tau^I) - e\tau^I \cdot \frac{\partial q^I(e,\tau^I)}{\partial e} - \frac{\partial C\left(q^I(e,\tau^I)\right)}{\partial q}\frac{\partial q^I(e,\tau^C,\lambda)}{\partial e}\right]$$
$$+(1-\lambda)\left[p\frac{\partial q^C(e,\tau^C)}{\partial e} - \tau^C q^C(e,\tau^C) - e\tau^C \cdot \frac{\partial q^C(e,\tau^C)}{\partial e} - \frac{\partial C\left(q^C(e,\tau^C)\right)}{\partial q}\frac{\partial q^C(e,\tau^C)}{\partial e}\right] - \frac{\partial K(e)}{\partial e} = 0$$

rearranging and invoking the envelope theorem,

$$\lambda\left[-\tau^I q^I(e,\tau^I)\right] + (1-\lambda)\left[-\tau^C q^C(e,\tau^C)\right] - \frac{\partial K(e)}{\partial e} = 0$$

Or,

$$-\frac{\partial K(e)}{\partial e} = \lambda\left[\tau^I q^I(e,\tau^I)\right] + (1-\lambda)\left[\tau^C q^C(e,\tau^C)\right] \tag{5}$$

Equation (5) yields the solution $e^u(\lambda, \tau^I, \tau^C)$, which is the carbon intensity choice under uncertainty, and states that the marginal benefit of reducing the per-good carbon intensity is equal to the expected savings in total tax payments from doing so.

It follows that the higher the expected tax τ, the more the firm will choose to abate. In a two party setting, this carbon intensity decision is a function of both parties' announced tax, but also of the instantaneous probability λ that the incumbent government will remain in power in period 2.

This result highlights the importance of policy credibility in influencing firms' abatement decisions. If firms anticipate significant policy uncertainty, they may under-invest in abatement (from the incumbent's point of view) due to the risk of a lower tax in the future. This aligns with the broader literature on policy-induced investment under uncertainty, where firms discount the effectiveness of future policies when they lack commitment mechanisms. In the next section, we quantify that risk and show how it affects the firm's profits, highlighting the cost of uncertainty .

3.3 The uncertainty cost

We now show how the uncertainty on τ is costly for the firm. Consider Ω, which will denote the policy uncertainty cost. This can be expressed by

$$\Omega = \tilde{\pi}(\tilde{q}, \tilde{e}, \tilde{\tau}) - \pi^u(q^u, e^u, \tau^u) \tag{6}$$

Note that $\pi^u(q^u, e^u, \tau^u)$ is the ex-post profit under uncertainty and that $\tilde{\pi}(\tilde{q}, \tilde{e}, \tilde{\tau})$ is an ex-post counterfactual and predictable profit. The easiest way to frame this term is to ask oneself "*Had the firm been able to optimize based on the true value of τ how would it have chosen q and e?*" Therefore, a no uncertainty framework can be interpreted as a problem where the firm would be able to choose both e and q simultaneously, when it observes τ. We express how the firm is always at least as better off in that situation, and therefore that uncertainty is costly. Under certainty,

$$\max_e \left\{ \max_q \pi(q, e, \tilde{\tau}) \right\} \equiv \max_{q,e} \pi(q, e, \tilde{\tau})$$

so let

$$\tilde{\pi}(\tilde{q}, \tilde{e}, \tilde{\tau}) = \max_{q,e} \pi(q, e, \tilde{\tau}) \ ;$$

Alternatively, let

$$\pi^u(q^u, e^u, \tau^u) = \max_{q} \pi(q, e^u, \tau^u) \quad \text{where} \quad e^u = \arg\max_{e} \mathbb{E}[\pi(q, e, \tau)]$$

where τ^u is an uncertain realization of the tax and where $\tilde{\tau} = \tau^u$ ex-post. Therefore, as soon as $\mathbb{E}[\tau] \neq \tau^u$, it follows that $e^u \neq \tilde{e}$ Then,

$$\tilde{\pi}(\tilde{q}, \tilde{e}, \tilde{\tau}) \geq \pi^u(q^*(e^u), e^u, \tau^u) \tag{7}$$

The firm abated either too much or not enough when $\mathbb{E}[\tau] \neq \tau^u$. Consequently, the only case where $\Omega = 0$ is when $\mathbb{E}[\tau] = \tau^u$ which means that the firm has perfectly predicted the period 1 policy. This is only true if $\lambda = 1$ or 0.

4 Carbon Contracts for difference

In this section, we turn to the case where the firm is able to utilize carbon contracts for difference (*CCfDs*). These contracts generate side-payments as soon as the effective carbon price, denoted τ diverges from the contract's strike price τ_s. Functionally, *CCfDs* operate similarly to existing contracts for differences (May et al. (2018), Kristiansen (2004)) for renewable energy, but with a focus on carbon emissions and carbon pricing. Instead of compensating for the difference between a fixed electricity price and the fluctuating market price, the public entity involved would cover the difference between a predetermined carbon price (strike price, or τ_s) and the actual market price for carbon emissions. Thus, *CCfDs* enable emission offset project developers to lock in a consistent and predictable carbon price throughout the contract term and the project's lifespan. Essentially, they serve as a hedge against carbon market risks or fluctuations in carbon pricing policies. We make no assumption on the nature of

the strike price, other than it must be such that the contract is incentive compatible for the firm. This will be explored in section 4.2

We make the deliberate decision to model *CCfDs* such that they do not exert an active influence on policy expectations in the same way as deficit accumulation. In Alesina and Tabellini (1990), the expectation of higher debt levels affects the economic behavior of future governments, forcing them to adjust taxation and expenditure plans accordingly. *CCfDs*, on the other hand, do not shape the policy preferences of future governments; they only ensure that pre-agreed transfers occur regardless of subsequent policy shifts. This means that while debt accumulation can create strategic distortions in fiscal policy, *CCfDs* operate more as financial instruments than as mechanisms of political constraint.

This distinction arises because, for *CCfDs* to function as a true commitment device that constrains future governments, their volume would need to be extraordinarily large relative to the overall fiscal capacity of the state. Additionally, the benefits of reversing the previous administration's climate policy would need to be weighted against its costs. Unlike public debt, which directly affects the government's aggregate budget and influences macroeconomic conditions, *CCfDs* only generate financial transfers tied to carbon price deviations. While these transfers can be significant at the sectoral level, they do not impose broad fiscal constraints that would systematically alter future policy decisions. In contrast, public debt directly impacts a government's ability to set spending and taxation priorities, making it a powerful tool for shaping policy expectations. By modeling *CCfDs* as compensation mechanisms rather than as binding commitments, we capture their role in mitigating investment risks without assuming they fundamentally restrict the policy space of future administrations. We however think that the commitment question is a central one, although outside the scope of the paper.

4.1 The sequential problem with *CCfDs*

Consider the following period 2 payment rule from the *Carbon Contract for Difference* mechanism

$$CCfD \text{ payment} = (\bar{e} - e)(\tau_s - \tau)q \tag{8}$$

Where τ_s is the strike price of the contract, which is determined in period 1 and where $(\bar{e} - e)$ is the measurable effort in reducing the carbon intensity from the baseline $\bar{e}$, where $\bar{e} \geq e$. This baseline can be viewed as a business as usual scenario, where no climate policy is in place. Payments can go either direction; if $\tau_s > \tau$, the government compensates the firm, but if $\tau_s < \tau$, the firm has to pay the government. Naturally, the period 0 participation constraint for the risk-neutral firm is therefore

$$\mathbb{E}[(\bar{e} - e)(\tau_s - \tau)q] \geq 0 \tag{9}$$

For (9) to hold, and thus for the firm to partake in the mechanism, it must be that expected compensations are positive, or equivalently, that

$$\tau_s \geq \lambda\tau^I + (1 - \lambda)\tau^C \tag{10}$$

Proposition 4.1 *When the expected CCfD transfers are positive, that is when offered* $\tau_s \geq \lambda\tau^I + (1 - \lambda)\tau^C$*, the risk-neutral firm enters the CCfD agreement.*

The firm's maximization problem with *CCfDs* is given by

$$\max_e \mathbb{E}\left[\underbrace{\max_q \left(pq - e\tau q + \underbrace{(\bar{e} - e)(\tau_s - \tau)q}_{CCfD} - C(q) \right)}_{\text{period 2}} - K(e)\right] \tag{11}$$

The first period problem, in a biparty system, is

$$\max_e \mathbb{E}[\pi] = \lambda \left[pq^I(e,\tau^I,\tau_s) - eq^I(e,\tau^I,\tau_s)\tau^I + \underbrace{(\tau_s - \tau^I)(\bar{e}-e)q^I(e,\tau^I,\tau_s)}_{CCfD} - C(q^I(e,\tau^I,\tau_s)) \right]$$
$$+ (1-\lambda) \left[pq^C(e,\tau^C,\tau_s) - eq^C(e,\tau^C,\tau_s)\tau^C + \underbrace{(\tau_s - \tau^C)(\bar{e}-e)q^C(e,\tau^C,\tau_s)}_{CCfD} - C(q^C(e,\tau^C,\tau_s)) \right] - K(e) \tag{12}$$

Starting with the period 2 problem, we get the first-order condition for $q^{ccfd}(e,\tau,\tau_s)$,

$$p - \tau \cdot e(\tau^I,\tau^C,\lambda,\tau_s) + (\bar{e} - e(\tau^I,\tau^C,\lambda,\tau_s)) \cdot (\tau_s - \tau) = \frac{\partial C(q)}{\partial q} \tag{13}$$

Where as before, $\tau \in \{\tau^I, \tau^C\}$. The firm now receives a direct transfer from the *CCfD*. When $\tau_s > \tau$, that transfer is strictly increasing in q. This is akin to a subsidy, which is added on to the sale price. When $\tau = \tau_s$, it is straightforward to see that no *CCfD* payments are made, and that the shape of (13) resembles that of (3).

Proposition 4.2 *When the firm enters the CCfD agreement, which by the participation constraint is when* $\tau_s \geq \lambda\tau^I + (1-\lambda)\tau^C$*, then* $q^{ccfd}(e,\lambda,\tau^I,\tau^C,\tau_s) > q^u(e,\lambda,\tau^I,\tau^C) \geq 0$ *since the expected contract payments are positive and act as an expected subsidy on production.*[2]

In expectations, (13) is expressed as

$$\mathbb{E}\left[p - \tau \cdot e(\lambda,\tau^I,\tau^C,\tau_s) + \left[\bar{e} - e(\lambda,\tau^I,\tau^C,\tau_s)\right](\tau_s - \tau) - \frac{\partial C(q)}{\partial q} \right] = 0$$

[2]The Proof of 4.2 can be found in the appendix, where we study both quadratic production costs and more general cost functions.

Where, with 2 political parties,

$$\begin{aligned}
&\lambda\left[p-\tau^I e(\lambda,\tau^I,\tau^C,\tau_s)+\left[\bar{e}-e(\lambda,\tau^I,\tau^C,\tau_s)\right](\tau_s-\tau^I)\right]\\
+(1-\lambda)&\left[p-\tau^C e(\lambda,\tau^I,\tau^C,\tau_s)+\left[\bar{e}-e(\lambda,\tau^I,\tau^C,\tau_s)\right](\tau_s-\tau^C)\right]\\
&=\lambda\frac{\partial C(q^I)}{\partial q}+(1-\lambda)\frac{\partial C(q^C)}{\partial q}
\end{aligned}\tag{14}$$

As before, the expected level of output $q^{ccfd}(e,\tau^I,\tau^C,\lambda,\tau_s)$ is a function of both parties' tax policy as well as of the probability that the incumbent remains in power. However, now that firms have access to *CCfDs*, they also take the strike price τ_s into account, as it dictates the size of the expected future transfers. Going back to the period 0 problem and taking the first-order condition with respect to e,

$$\begin{aligned}
&\lambda\Bigg[p\frac{\partial q^I(e,\tau^I,\tau_s)}{\partial e}-\tau^I q^I(e,\tau^I,\tau_s)-e\tau^I\cdot\frac{\partial q^I(e,\tau^I,\tau_s)}{\partial e}+\bar{e}(\tau_s-\tau^I)\frac{\partial q^I(e,\tau^I,\tau_s)}{\partial e}\\
&+(\tau_s-\tau^I)q^I(e,\tau^I)-e(\tau_s-\tau)\frac{\partial q^I(e,\tau^I,\tau_s)}{\partial e}-\frac{\partial C\left(q^I(e,\tau^I,\tau_s)\right)}{\partial q}\frac{\partial q^I(e,\tau^C,\tau_s)}{\partial e}\Bigg]\\
+(1-\lambda)&\Bigg[p\frac{\partial q^C(e,\tau^C,\tau_s)}{\partial e}-\tau^C q^C(e,\tau^C,\tau_s)-e\tau^C\cdot\frac{\partial q^C(e,\tau^C,\tau_s)}{\partial e}+\bar{e}(\tau_s-\tau^I)\frac{\partial q^I(e,\tau^I,\tau_s)}{\partial e}\\
&+(\tau_s-\tau^I)q^I(e,\tau^I,\tau_s)-(\tau_s-\tau)\frac{\partial q^I(e,\tau^I,\tau_s)}{\partial e}-\frac{\partial C\left(q^C(e,\tau^C,\tau_s)\right)}{\partial q}\frac{\partial q^C(e,\tau^C,\tau_s)}{\partial e}\Bigg]-\frac{\partial K(e)}{\partial e}=0
\end{aligned}\tag{15}$$

By the envelope theorem, using (13), (15) becomes

$$\begin{aligned}
&\lambda\Big[\tau^I q^I(e,\tau^I,\tau_s)+(\tau_s-\tau^I)q^I(e,\tau^I,\tau_s)\Big]\\
+(1-\lambda)&\Big[\tau^C q^C(e,\tau^C,\tau_s)+(\tau_s-\tau^C)q^C(e,\tau^C,\tau_s)\Big]=-\frac{\partial K(e)}{\partial e}
\end{aligned}$$

which yields

$$\begin{aligned}
&\lambda\Big[\tau_s q^I(e,\tau^I,\tau_s)\Big]+(1-\lambda)\Big[\tau_s q^C(e,\tau^C,\tau_s)\Big]=-\frac{\partial K(e)}{\partial e}\\
&\tau_s\left[\lambda q^I(e,\tau^I,\tau_s)+(1-\lambda)q^C(e,\tau^C,\tau_s)\right]=-\frac{\partial K(e)}{\partial e}
\end{aligned}\tag{16}$$

This states that the marginal benefit of reducing the per-good carbon intensity is equal to the expected savings in total tax payments from doing so. Now that the firm has access to carbon contracts for difference, the only part where uncertainty plays a role with regards to tax savings is through the period 1 expectation of the choice of $q^{ccfd}(e, \tau^I, \tau^C, \lambda, \tau_s)$ in the second period. This is the case since *CCfD* payments act as a compensation mechanism for any deviation from the strike price. Recall that one of the most important implications of this uncertainty is the potential for suboptimal investment (either too high, or too low). If the firm expects a high carbon price in the future, it will be incentivized to invest more in abatement to reduce its exposure to tax costs. However, if a new government takes power and lowers the carbon tax, the firm will have overinvested, resulting in a financial loss. Conversely, if the firm expects a low tax and underinvests in abatement, a higher-than-expected tax in period 2 will increase its costs significantly. This policy risk discourages firms from making aggressive investments in low-carbon technologies, as they cannot fully rely on announced policies. Instead, they hedge against uncertainty by adopting a more conservative investment approach, which limits the effectiveness of carbon pricing as a tool for emissions reduction.

The presence of *CCfDs* alters firm behavior in fundamental ways. Since the firm no longer has to worry about policy reversals or fluctuations in tax rates, it can make its investment decision based on a stable and predictable tax framework. This encourages greater abatement investment, as firms can confidently expect a return on their investments in emissions reduction. Unlike the full uncertainty case without *CCfDs*, where firms might hesitate to invest due to the risk of a lower-than-expected tax, *CCfDs* provide a guaranteed financial incentive to reduce emissions, leading to a higher level of abatement investment than would otherwise be the case. However, *CCfDs* do more than just stabilize expectations; they also change the firm's production incentives. Under uncertainty, a lower-than-expected tax would have benefited

the firm in two ways: first, by reducing its direct tax burden, and second, by enabling a higher level of production since the cost per unit of emissions would be lower. With *CCfDs*, this benefit is effectively neutralized because any deviation in the carbon price is compensated through the contract mechanism. The firm no longer experiences a gain from lower taxes, as the difference is automatically adjusted through *CCfD* payments. This means that the only remaining source of uncertainty comes from the expected production which still depends on the expected tax, but is less volatile than in the full uncertainty case. An additional consequence of *CCfDs* is their potential to induce overproduction. Because the *CCfD* structure effectively acts as a subsidy when the realized tax falls below the strike price, firms may have an incentive to increase production beyond socially optimal levels. This is particularly relevant in cases where the strike price is set too high, as firms could then receive substantial compensation payments while continuing to produce at a high level, partially offsetting the intended emissions reductions. The next section is dedicated to the study of the *CCfDs* role in implementing the incumbent government's subjective optimal level of carbon intensity (e) and production (q), where we study the aforementioned issues in more detail.

4.2 The implementation problem

While Carbon Contracts for Difference (*CCfDs*) can mitigate policy uncertainty and encourage low-carbon investments, their effectiveness as an implementation tool remains a critical question. In particular, even if *CCfDs* help align firms' expectations with a more stable carbon price, they do not necessarily ensure that the incumbent's government optimal levels of abatement and production - which we will define below - are achieved. The challenge lies in designing *CCfDs* that replicate the optimal investment and output decisions that would arise under a fully credible carbon pricing regime, from the *CCfD* emitter's standpoint. This section explores the conditions under which *CCfDs* can successfully implement the incumbent government's preferred

policy outcome and highlights the potential distortions that may arise if their design does not fully internalize firms' strategic responses.

4.2.1 Defining the incumbent's optimal outcome

Under certainty, the firm's problem can be written as

$$\max_{e} \pi = \underbrace{\max_{q} \left(pq - e\tau q - C(q)\right)}_{\text{period 2}} - K(e)$$

Let $\tau = \tau^I$ represent a credibly announced carbon tax, which is set equal to the social cost of carbon as perceived by the incumbent government in period 1 and which is implemented in period 2 with probability $\lambda = 1$. Conceptually, this is the firm's problem under certainty, where the period 1 government is sure to be re-conducted and thus, where there is no politically induced investment risk. Precisely, this specification reflects the optimal policy choice from the perspective of the initial government, given its own assessment of the social cost of carbon. We remain agnostic with respect to the normative validity of this particular valuation of the social cost of carbon and therefore make no ethical argument regarding the choice of τ^I. The corresponding first-order conditions that characterize this policy choice are given by

$$-\frac{\partial K(e^I)}{\partial e} = \tau^I \cdot q^{I*}(e^I, \tau^I) \text{ period 1}$$

and

$$p - \tau^I e^{I*}(\tau^I) = \frac{\partial C(q^I)}{\partial q} \text{ period 2}$$

Where both $C(q)$ and $K(e)$ are strictly convex and at least twice differentiable.

From the incumbent government's perspective, using a *CCfD* regime as an implemen-

tation device would imply that both $e^{ccfd}(\lambda, \tau^I, \tau^C, \tau_s) = e^{I*}(\tau^I)$ and $q^{ccfd}(e^{ccfd}, \tau, \tau_s) = q^{I*}(e^I, \tau^I)$ hold, since this is the most efficient way of achieving the target emission level. Remember that the firm's problem is solved by backward induction. Let us first recall the first order conditions under *CCfDs*. For readability purposes, we lighten the notation and let $q^{ccfd}(e^{ccfd}, \tau, \tau_s) \equiv q^{ccfd}$ and $e^{ccfd}(\lambda, \tau^I, \tau^C, \tau_s) \equiv e^{ccfd}$

In period 1:

$$\tau_s \left[\underbrace{\lambda q^I_{ccfd}(e, \tau^I, \tau_s) + (1-\lambda) q^C_{ccfd}(e, \tau^C, \tau_s)}_{\mathbb{E}[q^{ccfd}]} \right] = -\frac{\partial K(e^{ccfd})}{\partial e} \tag{17}$$

In period 2:

$$p - \tau \cdot e^{ccfd} + (\bar{e} - e^{ccfd}) \cdot (\tau_s - \tau) = \frac{\partial C(q^{ccfd})}{\partial q} \tag{18}$$

Where the period 1 expectation of (18) is (13). Since both $C(q)$ and $K(e)$ are strictly convex and twice differentiable, then $\frac{\partial^2 C(q)}{\partial q^2} > 0$ and $\frac{\partial^2 K(e)}{\partial k^2} > 0$. Therefore both $\frac{\partial C(q)}{\partial q}$ and $\frac{\partial K(e)}{\partial e}$ are monotonically increasing and injective functions. If $\frac{\partial C(q^I)}{\partial q} = \frac{\partial C(q^{ccfd})}{\partial q}$ then $q^{I*} = q^{ccfd}$ and similarly, if $\frac{\partial K(e^I)}{\partial e} = \frac{\partial K(e^{ccfd})}{\partial e}$, then $e^{I*} = e^{ccfd}$. We now study under which conditions a *CCfD* can, or cannot, act as an implementation device for the incumbent government.

4.2.2 Can the incumbent implement $e^{I*}(\tau^I)$ and $q^I(e^I, \tau^I)$?

The first step is to recall in which case entering a *CCfD* agreement is incentive compatible for the firm. Remember the *CCfD* payment function

$$CCfD \text{ payment} = (\tau_s - \tau)(\bar{e} - e)q$$

Where we have shown, from (4.1), that the firm enters the agreement only if

$$\tau_s \geq \lambda\tau^I + (1-\lambda)\tau^C$$

Case 1: $\tau_s = \tau^I$

The first case to consider is that when the government sets $\tau_s = \tau^I$ in period 1. In the event where it is still in power in period 2, it sets an effective tax rate equal to the strike price and the *CCfD* payments are null. However, from incentive compatibility, the firm entered the *CCfD* agreement with beliefs $\tau_s \geq \lambda\tau^I + (1-\lambda)\tau^C$. Therefore, it follows from the expected period 2 first-order condition that $\mathbb{E}[q^{ccfd}] \geq q^{I*}(e^I, \tau^I)$ since positive expected *CCfD* payments generate an incentive to increase production and have the same effect as a subsidy.

Going back to the period 1 f.o.cs, if the government sets $\tau_s = \tau^I$, we can deduce that since $\mathbb{E}[q^{ccfd}] \geq q^{I*}(e^I, \tau^I)$, then

$$\tau_s \left[\lambda q^I(e, \tau^I, , \tau_s) + (1-\lambda) q^C(e, \tau^C, \tau_s)\right] \geq \tau^I \cdot q^{I*}(e^I, \tau^I)$$
$$\left[\lambda q^I(e, \tau^I, \tau_s) + (1-\lambda) q^C(e, \tau^C, \tau_s)\right] \geq q^{I*}(e^I, \tau^I)$$

Where the inequality is binding only if $\lambda = 1$, or if $\tau^I = \tau^C$, or both. This is equivalent to a case where there is no uncertainty and thus, is not of interest. We ignore that corner solution. For $\tau_s = \tau^I$,

$$\tau_s \mathbb{E}[q^{ccfd}] > \tau^I q^{I*}(e^I, \tau^I) \tag{19}$$

Accordingly, (19) implies that

$$\frac{\partial K(e^I)}{\partial e} < \frac{\partial K(e^{ccfd})}{\partial e}$$

Using the strict convexity of $K'(e)$, we can conclude that $e^{ccfd}(\lambda, \tau^I, \tau^C, \tau_s) < e^{I*}(\tau^I)$

Proposition 4.3 *When the incumbent government sets the strike price τ_s equal to its certainty-optimal tax τ^I, the firm invests too much in reducing its carbon intensity and $e^{ccfd}(\lambda, \tau^I, \tau^C, \tau_s) < e^{I*}(\tau^I)$.*

From the incumbent's point of view, this result is not *ex-ante* optimal since the existence of expected positive *CCfD* transfers to the firm (in period 1), which act as a subsidy, mean that the firm will expect higher production in period 2, and as a result will over-invest in reducing its carbon intensity, as compared to the incumbent's optimal policy without uncertainty. Such an outcome holds because the size of the transfer strictly increases with effort $(\bar{e} - e)$. Therefore, regardless of who is in power in period 2, the fact that e^I is not implementable naturally implies that a *CCfD* where $\tau_s = \tau^I$ never implements the incumbent's investment and production outcome. Note that this results relies on the assumption that the government has a unique optimal tax rate τ^I for both periods and that it does not manipulate it ex-post, once the investment in $e^{ccfd}(\lambda, \tau^I, \tau^C, \tau_s)$ is realized. In other words, the uncertainty is not about whether or not the incumbent government will implement what it promised, but rather on the fact that the firm doesn't know if it will still be in power in period 2.

Case 2: $\tau_s > \tau^I$

This case is trivial. We have seen from *case 1* that when the participation constraint $\tau_s \geq \lambda\tau^I + (1-\lambda)\tau^C$ holds and when $\tau_s = \tau^I$, then $\tau_s \mathbb{E}[q^{ccfd}] > \tau^I q^{I*}(e^I, \tau^I)$ and it must be that $e^{ccfd}(\lambda, \tau^I, \tau^C, \tau_s) < e^{I*}(\tau^I)$. Therefore it follows that setting $\tau_s > \tau^I$ also yields $e^{ccfd}(\lambda, \tau^I, \tau^C, \tau_s) < e^{I*}(\tau^I)$, always.

Case 3: $\tau_s < \tau^I$

In *case 1*, we have shown that setting the strike price equal to the incumbent's social cost of carbon τ^I yields over-investment. We now consider the situation where the government sets some $\tau_s < \tau^I$. Now again, from the participation constraint, we know that if the firm entered the agreement, then its beliefs are such that $\tau_s >$

$\lambda\tau^I + (1-\lambda)\tau^C$ and again that $\mathbb{E}[q^{ccfd}] > q^{I*}(e^I, \tau^I)$ from 4.2. Going back to the period 1 first-order condition, e^I is implementable if and only if

$$\tau_s \cdot \mathbb{E}[q^{ccfd}] = \tau^I \cdot q^{I*}(e^I, \tau^I)$$
$$\tau_s \left[\lambda q^I(e, \tau^I, , \tau_s) + (1-\lambda) q^C(e, \tau^C, \tau_s)\right] = \tau^I \cdot q^{I*}(e^I, \tau^I)$$

Rearranging,

$$\tau_s = \tau^I \cdot \underbrace{\frac{q^{I*}(e^I, \tau^I)}{\lambda q^I(e, \tau^I, \tau_s) + (1-\lambda) q^C(e, \tau^C, \tau_s)}}_{<1} \tag{20}$$

Equation (20) generates important implications. First, notice that the denominator is a weighted average of production under *CCfDs* and a composite of two implicit functions of τ_s. Therefore, as both $q^I(e, \tau^I, \tau_s)$ and $q^C(e, \tau^C, \tau_s)$ are increasing in τ_s, that suggests a dampening effect: the more responsive output is to τ_s, the smaller the needed strike price. Second, for the equality to hold, it must be that $\lambda q^I(e, \tau^I, \tau_s) + (1-\lambda) q^C(e, \tau^C, \tau_s) > q^{I*}(e^I, \tau^I)$, for any $\lambda \in (0, 1)$. We know that in the case where $\tau_s < \tau^I$, then

$$q^I(e, \tau^I, \tau_s) < q^{I*}(e^I, \tau^I)$$

since when the incumbent is reelected, the contract's transfers are such that the firm has to pay the government for each unit produced. By incentive compatibility, it must accordingly be that

$$\tau^I > \tau_s > \tau^C \tag{21}$$

over a certain interval of reelection probability λ. This yields a trivial, yet important result. In a biparty system, the incumbent can credibly offer *CCfDs* only if its tax τ^I is more ambitious than the challenger's announced tax τ^C. Intuitively, for the firm to accept the contract, it must be that the probability of receiving payments is at

least greater than zero. Hence, given τ^I and τ^C, we can identify a set of λ for which a strike price that implements $e^{I*}(\tau^I) = e^{ccfd}(\lambda, \tau^I, \tau^C, \tau_s)$ exists. Take

$$\begin{aligned}
\lambda q^I(e, \tau^I, \tau_s) + (1-\lambda) q^C(e, \tau^C, \tau_s) &> q^{I*}(e^I, \tau^I) \\
\lambda q^I(e, \tau^I, \tau_s) + q^C(e, \tau^C, \tau_s) - \lambda q^C(e, \tau^C, \tau_s) &> q^{I*}(e^I, \tau^I) \\
\lambda [q^I(e, \tau^I, \tau_s) - q^C(e, \tau^C, \tau_s)] &> q^{I*}(e^I, \tau^I) - q^C(e, \tau^C, \tau_s)
\end{aligned}$$

Which implies

$$0 < \lambda < \frac{q^C(e, \tau^C, \tau_s) - q^{I*}(e^I, \tau^I)}{q^C(e, \tau^C, \tau_s) - q^I(e, \tau^I, \tau_s)} < 1 \tag{22}$$

From $\tau^C < \tau^I$, the second period first-order condition signifies that the denominator is positive. Hence,

$$\begin{aligned}
q^C(e, \tau^C, \tau_s) - q^{I*}(e^I, \tau^I) &< q^C(e, \tau^C, \tau_s) - q^I(e, \tau^I, \tau_s) \\
q^{I*}(e^I, \tau^I) &> q^I(e, \tau^I, \tau_s)
\end{aligned} \tag{23}$$

Proposition 4.4 *There exists a set of* $\lambda \in \left(0, \frac{q^C(e,\tau^C,\tau_s) - q^{I*}(e^I,\tau^I)}{q^C(e,\tau^C,\tau_s) - q^I(e,\tau^I,\tau_s)}\right)$ *for which there are strike prices defined by* $\tau^I > \tau_s > \tau^C$*, such that the CCfD induces the incumbent's optimal carbon intensity* $e^{I*}(\tau^I)$

Equation (23) suggests that there exists no combination of $\lambda, \tau^I, \tau^C, \tau_s$ which implements the incumbent government's optimal production plan $q^{I*}(e^I, \tau^I)$. When the incumbent is reappointed, the existence of payments from the firm to the government reveal under-production, since those payments are a markup on the marginal production cost. Alternatively, when the challenger gains power, (21) and (23) indicate that

$$q^C(e, \tau^C, \tau_s) > q^{I*}(e^I, \tau^I) \tag{24}$$

Consequently, if the challenger wins the election, it sets $\tau^C < \tau_s$ and the government pays the firm for each unit produced. This is akin to a production subsidy and it results in over-production from the incumbent's perspective.

Proposition 4.5 *There exists no combination of* $\lambda, \tau^I, \tau^C, \tau_s$ *that implements the incumbent's optimal level of production* $q^{I*}(e^I, \tau^I)$

Even in the absence of policy deviation, where the incumbent government would manipulate $\tau \neq \tau^I$ after the investment is made, we find that it is impossible to induce both the optimal carbon intensity level e^{I*} and the optimal production plan q^{I*} through carbon contracts for difference.

5 Discussion

5.1 Carbon intensity and the rebound effect

Our results demonstrate that contracts for carbon differences (*CCfDs*) can reduce the cost of uncertainty for clean technology investment, especially in politically unstable settings. By guaranteeing a minimum carbon price, *CCfDs* provide firms with revenue certainty, mitigating the policy risk that future governments may reverse or weaken carbon pricing regimes. However, this insurance function comes at a cost. In the event that the incumbent government loses power and its successor rolls back carbon pricing, the *CCfD* obliges the state to compensate the firm for the difference between the guaranteed and actual carbon prices. While this ensures investor protection, it also introduces a new form of distortion. If the firm continues to receive payments as though the carbon price were high — even though the actual carbon price is low or zero — it may have an incentive to increase output beyond the contract emitter's - that is the incumbent - optimum. This generates a rebound effect: the guaranteed revenue stream decouples production decisions from carbon externalities and decrease the marginal cost of production, resulting in higher production than

would have occurred under the incumbent's original carbon pricing regime.

In essence, the *CCfD* stabilizes investment incentives but not emissions outcomes. Once the political environment shifts and the carbon price collapses, the firm still benefits from the shadow price embedded in the *CCfD*, but now faces lower marginal costs of production. Unless the contract includes quantity-based safeguards or regulatory constraints, the result is a level of production that exceeds what would be socially optimal under the previously higher carbon prices. This undermines the environmental integrity of the policy and raises questions about long-term climate effectiveness. This result introduces a fundamental intertemporal trade-off: *CCfDs* can align private investment with long-term decarbonization goals, but at the risk of locking in emissions trajectories that may become misaligned with future political realities. This suggests that *CCfDs* may be most appropriate when paired with additional mechanisms — such as production limits, performance standards, or clawback provisions — that could realign incentives in the event of major policy shifts. We do not explore these solutions, but think that they might be relevant for future work.

Furthermore, this rebound mechanism highlights the deeper normative question of democratic accountability. By guaranteeing payments independent of future policy choices, CCfDs bind future governments to fiscal commitments made by their predecessors. This may be justifiable in the name of investment certainty and climate ambition, but it also raises concerns about intergenerational fairness and policy rigidity. Future administrations may find themselves compensating firms for emissions that are no longer politically or socially desirable. We will further elaborate on this issue in section (5.3)

5.2 The flexibility cost of *CCfDs*

The irreversibility of financial commitments embedded in *CCfDs* can lead to policy lock-in, whereby future governments are disincentivized from pursuing alternative climate strategies. From an economic perspective, such lock-in may be seen as beneficial, providing policy stability that reduces investment risks. However, from a democratic standpoint, this stability comes at the cost of flexibility and responsiveness. If future electorates prioritize alternative approaches—such as direct regulation, carbon taxation, or localized climate initiatives—CCfDs may limit the feasibility of such shifts due to the financial penalties associated with contract termination. The literature on dynamic inconsistency in public policy (Kydland and Prescott (1977)) acknowledges the need for credible commitments. Yet, when these commitments curtail democratic adaptability, the trade-off between credibility and flexibility becomes problematic.

By design, *CCfDs* commit the government to a pre-specified carbon price floor over a long time horizon. This contractual rigidity limits the government's ability to adjust its climate policy instruments in response to new information — about technology costs, abatement opportunities, or broader economic conditions. For example, should abatement become cheaper than anticipated due to a technological breakthrough, or should emissions fall below projections due to macroeconomic changes, a rational policymaker might prefer to reduce the carbon price or shift to a different instrument mix. However, under *CCfDs*, any such downward adjustment triggers fiscal liabilities: the government must compensate firms for the shortfall relative to the guaranteed price. This can make climate policy path-dependent and politically sticky, even in cases where flexibility would be welfare-improving. Moreover, *CCfDs* may entrench specific technology choices. Since firms make investment decisions based on the *CCfD*-backed price, technologies that are marginal today but projected to become competitive in the future may be locked out. Conversely, technologies that are viable only under a guaranteed price may be scaled up — even if they become suboptimal

relative to other options down the line. In this way, *CCfDs* can bias the technological portfolio, not through central planning but through market commitments backed by government credibility. This may lead to inefficient capital allocation in the long term, especially if the original *CCfD* design was based on imperfect foresight or overly optimistic projections.

Importantly, this flexibility cost is not symmetric. Governments are free to increase ambition — by tightening carbon pricing or layering additional policies — without triggering *CCfD* payouts. It is only downward adjustments that activate fiscal transfers (from the government to the firm). This asymmetry creates an implicit bias toward policy ratcheting: once the *CCfD* floor is set, the cost of retreating from it is politically and fiscally salient, whereas the cost of overshooting is not. While this may be desirable in some climate-policy contexts, it limits the government's ability to adapt optimally in the face of uncertainty, including surprises that shift the marginal abatement cost curve downward. While these issues are not modeled in this work, we think that they should be studied carefully.

One possible remedy is to design *CCfDs* with built-in review clauses, allowing for conditional renegotiation in response to pre-specified signals (e.g. large technology cost declines, major geopolitical shifts, or emissions shortfalls). However, such flexibility mechanisms must be carefully designed to avoid reintroducing policy risk. If the conditions for renegotiation are vague or too easily invoked, investors will discount the credibility of the contract (Hart and Moore (1988)). Conversely, overly rigid designs may negate the benefits of adaptive climate governance. Striking the right balance between commitment and flexibility remains one of the core design challenges of *CCfDs*.

5.3 *CCfDs* as a (anti) democratic tool

By guaranteeing a fixed carbon price over a specified period, *Carbon Contracts for Difference (CCfDs)* provide long-term certainty for investors, thereby facilitating large-scale decarbonization projects. However, while their economic rationale is compelling — particularly in contexts plagued by political volatility or policy uncertainty — some might argue that *CCfDs* raise fundamental questions about democratic governance. Specifically, the binding nature of these contracts, which obligates governments to honor compensation schemes irrespective of future political shifts, may undermine the democratic principle that current governments should not constrain the policy space of their successors (Maskin and Tirole (2004); Besley and Coate (2001)). A central tenet of democratic accountability is the capacity of successive governments to adapt policies in accordance with evolving public preferences. Yet *CCfDs* impose long-term fiscal obligations that transcend electoral cycles, potentially limiting the space for future political change. Such guarantees effectively bind future administrations to fiscal responsibilities determined by their predecessors, regardless of subsequent shifts in public opinion or electoral outcomes. This arrangement raises concerns regarding democratic legitimacy, as future voters may find their policy preferences constrained by decisions made in the past. This democratic deficit is further exacerbated by the delayed visibility of *CCfD*-related expenditures. Often, the fiscal implications of *CCfDs* — particularly in cases where market carbon prices fall far below the strike price — do not materialize until several years after the contracts are signed. This temporal disconnect makes retrospective accountability difficult. Citizens may bear the fiscal consequences of commitments they were not aware of, or did not support at the time of their inception. As emphasized in the literature on fiscal transparency and intertemporal policy design, such dynamics weaken the link between democratic will and budgetary outcomes (Persson et al. (1997)).

Moreover, the intertemporal nature of *CCfDs* raises issues of intergenerational

equity. By committing future public funds to compensate private investors, present-day governments may reduce the fiscal flexibility available to future generations — precisely at a time when these generations may face new or more urgent climate, social, or economic challenges. The principle of intergenerational justice, central to both democratic theory and environmental economics, asserts that no generation should impose undue constraints on the policy autonomy or welfare of those that follow (Rawls (1971)). Insofar as *CCfDs* shift risk forward in time, they risk violating this principle. Indeed, in the absence of complementary institutional safeguards (e.g., parliamentary oversight, sunset clauses, or contingent escape options), such contracts could lock in spending patterns that crowd out future climate or social priorities (see Alesina and Tabellini (1990)).

Yet, the critique of *CCfDs* as "anti-democratic" relies on a narrow conception of democracy as policy reversibility. A more capacious view would acknowledge that democracy also requires institutions that credibly uphold prior democratic decisions, particularly when those decisions involve long-term societal goals. In this broader frame, *CCfDs* function as instruments of democratic continuity. They translate policy mandates — often resulting from democratic deliberation and electoral competition — into credible, durable commitments that survive beyond a single electoral cycle. In this sense, *CCfDs* enhance what might be called *ex-ante* democratic legitimacy. Their existence allows electorates to vote for climate ambition and have those preferences implemented, even in the face of later political turnover. The literature on time inconsistency and commitment in political economy provides useful parallels here. As Kydland and Prescott (1977) and more recently Harstad (2020) argue, political actors often lack the incentives or ability to implement policies with long-run payoffs, particularly when re-election incentives dominate. In such settings, commitment devices — including independent agencies, fiscal rules, or contracts like *CCfDs* — can help overcome this gap between stated preferences and actual out-

comes. Without such mechanisms, electorates may find themselves repeatedly voting for climate action, only to witness policy reversals or implementation failures. This cycle erodes both policy effectiveness and citizen trust.

Moreover, *CCfDs* mitigate a distinct market failure: the hold-up problem that arises when private investors anticipate future policy reversal. By providing credible guarantees, *CCfDs* de-risk capital flows into clean technologies — translating voter preferences for decarbonization into concrete infrastructure. In doing so, they align long-term societal objectives with private incentives, a core challenge in dynamic public economics. Ultimately, the democratic tension posed by *CCfDs* is not between commitment and accountability, but between different dimensions of accountability: responsiveness to evolving preferences versus responsibility to past mandates. Viewed this way, *CCfDs* are not inherently anti-democratic; they are a means of preserving democratic intent over time, in a political environment that is often short-sighted and institutionally fragmented.

From a policy perspective, our findings suggest that *CCfDs* should not be viewed as neutral financial instruments but as deeply political tools that redistribute risks across time and across governments. Their design must therefore account not only for technological cost curves and market dynamics, but also for the political economy in which they operate. This has implications for the optimal length, size, and fiscal treatment of CCfDs, as well as for complementary institutional safeguards—such as parliamentary oversight, sunset clauses, or flexible renegotiation mechanisms—that can mitigate their rigidity without eroding credibility. We think that this is grounds for future work.

6 Conclusion

This paper analyzes the political and economic consequences of Carbon Contracts for Difference (*CCfDs*), a rapidly emerging instrument in the global climate policy toolkit. *CCfDs* are designed to provide revenue certainty to firms investing in clean technologies by guaranteeing a fixed carbon price over time. While their economic rationale is increasingly recognized—particularly for catalyzing investments in capital-intensive, emissions-reducing technologies—our analysis emphasizes the intertemporal political economy frictions these instruments generate.

Under certain conditions, we show that CCfDs can enable an incumbent government to induce its optimal investment level over multiple electoral cycles. In doing so, they reduce policy risk and help resolve a classic "hold-up" problem that deters private investment in clean technologies. Our model formalizes this intuition: in the absence of a *CCfD*, the government's re-election uncertainty leads to underinvestment in clean production. With *CCfDs*, *ex-ante* efficient investment can be contracted, but at the cost of reduced flexibility and potentially inefficient emissions trajectories in the future. Two central trade-offs emerge. First, while CCfDs mitigate under-investment by de-risking future cash flows, they may also distort emissions outcomes depending on the political trajectory. When the government that initially signed the contract is not re-elected, a less climate-ambitious successor inherits binding financial commitments, loses its ability to influence the marginal incentive to pollute, and may find itself overseeing overproduction of the clean good due to lower-than-optimal emission prices. This leads to a novel political rebound effect, whereby intertemporal contracting, meant to stabilize investment, generates excess emissions in a context of political misalignment. Conversely, when the incumbent is re-elected, the long-term contract may result in underproduction. In this case, the firm—facing a high prevailing carbon price and obligated under the CCfD to make compensation payments to the government—has weaker incentives to produce. The intended

transfer flips direction, reducing the firm's effective revenue and discouraging output even though the environmental price signal is aligned with the incumbent's *ex-ante* optimum. This reflects a subtle but central distortion: the contract, while providing intertemporal insurance, creates inefficiencies even when each party's preferences remain stable. Together, these two cases underscore how *CCfDs*, despite their appeal as implementation devices, introduce asymmetric distortions depending on the political state of the world.

Second, *CCfDs* entail a cost of flexibility: by insuring investors against political risk, they constrain the state's future ability to adjust climate policies in response to new information or shifting public preferences. This limitation may be welfare-enhancing if it prevents inefficient policy reversals, but can also lead to suboptimal rigidity, especially under conditions of high political volatility or macroeconomic uncertainty. We discuss how the value of commitment must be weighed against the cost of locking in a potentially inefficient policy path. Beyond the formal results, the paper raises important questions about the democratic legitimacy and intergenerational fairness of *CCfDs*. These contracts effectively shift fiscal risks onto future governments and taxpayers, potentially binding them to financial obligations that no longer reflect political or economic priorities. While some may interpret this as a democratic deficit, we argue that *CCfDs* can also enhance democratic governance by ensuring that electorally endorsed climate mandates are credibly implemented. In that sense, they promote democratic continuity rather than erosion, helping bridge the gap between voter preferences and policy outcomes in the presence of political turnover.

Ultimately, this paper underscores a fundamental tension in climate policy: achieving credible, long-term investment signals often requires insulating policy from politics—yet climate policy, by its nature, is inherently political. Navigating this tension

requires not only economic tools like *CCfDs*, but also a careful institutional architecture that balances commitment with accountability, and long-term credibility with democratic responsiveness.

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Appendix - Proof of Proposition 4.2 (quadratic costs)

We want to show that

$$\mathbb{E}[q^{cc}(\tau, \tau_s) - q^u(\tau)] > 0 \quad \text{if} \quad \mathbb{E}[\tau] < \tau_s$$

We know that: if $\tau < \tau_s$,

$$q^{cc}(\tau, \tau_s) - q^u(\tau) > 0 \quad \text{and} \quad q^{cc}(\mathbb{E}[\tau], \tau_s) - q^u(\mathbb{E}[\tau]) > 0$$

Proof

Recall the period-1 first-order conditions Under uncertainty:

$$p - \tau e = \frac{\partial C(q(\tau))}{\partial q}$$

Differentiating with respect to τ, we get

$$\begin{aligned} -e^u &= \frac{\partial^2 C(q(\tau))}{\partial q^2} \cdot \frac{dq(\tau)}{d\tau} \\ \frac{dq(\tau)}{d\tau} &= \frac{-e^u}{\frac{\partial^2 C(q(\tau))}{\partial q^2}} \end{aligned} \tag{25}$$

For notational simplicity, rewrite (25) as

$$q^{u'}(\tau) = \frac{-e^u}{C''((q^u(\tau))} \tag{26}$$

Where the superscript u denotes the uncertainty case without *CCfDs*. Equivalently, for the *CCfD* case, we differentiate the following with respect to τ

$$p - \tau e + (\bar{e} - e)(\tau_s - \tau) = \frac{\partial C(q)}{\partial q}$$

which yields

$$-e^{cc} - \bar{e} + e^{cc} = C''((q^{cc}(\tau, \tau_s)) \cdot q^{cc'}(\tau, \tau_s)$$
$$q^{cc'}(\tau, \tau_s) = \frac{-\bar{e}}{C''((q^{cc}(\tau, \tau_s))}$$

We now need to prove that the following inequality holds, to show that the variation in quantities is a convex function. Taking the second derivative:

$$\mathbb{E}\left[q^{cc''}(\tau, \tau_s) - q^{u''}(\tau)\right] = -\frac{(q^{cc'}(\tau, \tau_s))^2 C'''(q^{cc}(\tau, \tau_s))}{C''(q^{cc}(\tau, \tau_s))} + \frac{(q^{u'}(\tau))^2 C'''(q^{u}(\tau))}{C''(q^{u}(\tau))} \geq 0 \tag{27}$$

If costs are quadratic, then $C'''(\cdot) = 0$ and (27) holds with strict equality and the right-hand side is equal to 0. What remains to be shown is that $\mathbb{E}[q^{cc'}(\tau, \tau_s) - q^{u'}(\tau)] < 0$. Since $C''(q^u(\tau))$ and $C''(q^{cc}(\tau, \tau_s))$ are a positive constant when costs are quadratic and recalling that $\bar{e} > e$,

$$\mathbb{E}[q^{cc'}(\tau, \tau_s) - q^{u'}(\tau)] = \frac{e - \bar{e}}{C''(\cdot)} < 0 \tag{28}$$

Thus, $\mathbb{E}[q^{cc}(\tau, \tau_s) - q^u(\tau)]$ is decreasing in τ. Furthermore, from quadratic costs, $\mathbb{E}[q^{cc}(\tau, \tau_s) - q^u(\tau)]$ is also linear in τ, we can invoke Jensen's inequality for linear functions:

$$\mathbb{E}[q^{cc}(\tau, \tau_s) - q^u(\tau)] = q^{cc}(\mathbb{E}[\tau], \tau_s) - q^u(\mathbb{E}[\tau]).$$

Finally, since $\tau < \tau_s$ implies $\mathbb{E}[q^{cc}(\tau, \tau_s) - q^u(\tau)] > 0$, we conclude:

$$\mathbb{E}[q^{cc}(\tau, \tau_s) - q^u(\tau)] > 0 \quad \text{if} \quad \mathbb{E}[\tau] < \tau_s.$$

Appendix - Proof of Proposition 4.2 (more general costs)

Start again from (27)

$$\mathbb{E}\left[q^{cc''}(\tau,\tau_s)-q^{u''}(\tau)\right]=-\frac{(q^{cc'}(\tau,\tau_s))^2C'''(q^{cc}(\tau,\tau_s))}{C''(q^{cc}(\tau,\tau_s))}+\frac{(q^{u'}(\tau))^2C'''(q^{u}(\tau))}{C''(q^{u}(\tau))}\geq 0 \tag{29}$$

With

$$q^{cc'}(\tau,\tau_s)=\frac{-\bar{e}}{C''((q^{cc}(\tau,\tau_s))} \text{ and } q^{u'}(\tau)=\frac{-e^u}{C''((q^{u}(\tau))}$$

rewriting,

$$\frac{e^{u^2}C'''(q^u)}{C''(q^u)^3}\geq\frac{\bar{e}^2C'''(q^{cc})}{C''(q^{cc})^3}$$

Since $\bar{e}\geq e^u$, this inequality holds if

$$C'''(\cdot)\leq 0$$

As in the quadratic case, we now examine the sign of the expected difference in marginal responses:

$$\begin{aligned}\mathbb{E}[q^{cc'}(\tau,\tau_s)-q^{u'}(\tau)]&=\mathbb{E}\left[\frac{-\bar{e}}{C''(q^{cc}(\tau,\tau_s))}-\frac{-e^u}{C''(q^{u}(\tau))}\right]\\&=\mathbb{E}\left[\frac{e^u}{C''(q^{u}(\tau))}-\frac{\bar{e}}{C''(q^{cc}(\tau,\tau_s))}\right]\end{aligned} \tag{30}$$

To determine the sign of the expression in (30), consider

$$\mathbb{E}[q^{cc'}(\tau,\tau_s)-q^{u'}(\tau)]=\mathbb{E}\left[\frac{e^u}{C''(q^{u}(\tau))}-\frac{\bar{e}}{C''(q^{cc}(\tau,\tau_s))}\right].$$

if

$$\frac{C''(q^{cc}(\tau,\tau_s))}{C''(q^u(\tau))} < \underbrace{\frac{\bar{e}}{e^u}}_{\geq 0},$$

then it follows that

$$\frac{e^u}{C''(q^u(\tau))} - \frac{\bar{e}}{C''(q^{cc}(\tau,\tau_s))} < 0,$$

and hence

$$\mathbb{E}[q^{cc'}(\tau,\tau_s) - q^{u'}(\tau)] < 0.$$

That is, the function $q^{cc}(\tau,\tau_s) - q^u(\tau)$ is decreasing in τ. Invoking Jensen's inequality for convex functions:

$$\mathbb{E}[q^{cc}(\tau,\tau_s) - q^u(\tau)] \geq q^{cc}(\mathbb{E}[\tau],\tau_s) - q^u(\mathbb{E}[\tau])$$

Finally, since $\mathbb{E}[\tau] < \tau_s$ implies $q^{cc}(\mathbb{E}[\tau],\tau_s) - q^u(\mathbb{E}[\tau]) > 0$, we conclude:

$$\mathbb{E}[q^{cc}(\tau,\tau_s) - q^u(\tau)] > 0 \quad \text{if} \quad \mathbb{E}[\tau] < \tau_s.$$