Climate Change Economics: Bridging the Gap Between Scientific Urgency and Policy Inaction

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ABSTRACT

The global scientific consensus regarding the urgent threat from climate change is arguably at odds with the far from substantial and fragmented nature of global policy responses. The paper examines the economic reasons for the absence of coordinated policy response focused on climate change, from basic market failure with respect to negative externalities, to the political economy of vested interests and the challenges of international coordination. The paper critically reviews the main economic tools to promote and embed climate change policy, including carbon pricing tools and green subsidies, and assesses how they perform in a real-world context. The paper argues that the gap between scientific recommendations and political realities can be addressed with a new generation of integrated policy tools that are economically efficient, politically acceptable and socially equitable. The paper ends with several suggestions for policy makers to align long-term environmental objectives with short-term economic incentives to enable a global response to climate change that is both stronger and quicker.

Keywords: Social cost of carbon, Carbon pricing mechanisms, Political economy of climate policy, Integrated assessment models, Border carbon adjustments

Introduction

The current scientific consensus regarding anthropogenic climate change is irrefutable. The Intergovernmental Panel on Climate Change (IPCC), along with numerous national and international scientific agencies, have presented the empirical evidence of climate change: in particular, impacts of climate change will bring maladaptive responses: sea-level rise, weather volatility, food scarcity, human displacement and potentially existential threats to both global stability and global prosperity. These voices cry out from the same hymn-sheet: ourselves, our children, and grandchildren are at risk. But for whatever reasons, human beings either have problems responding rationally to the existential threats posed by climate change or their response demonstrates a marked difference between the claims of scientists and the politically/culturally engineered inertia of humans. This paper argues that this phenomenon, the difference between scientific urgency and human political responses is economic in nature, via misaligned incentives, market failures, and the complex political-dimensions of the issues at hand. This paper will consider the economic basis for climate change and economic-based policies and use them to infer the barriers to their adoption. Finally, it will make some suggestions of how to reconcile scientific agreement to political realities.

The Economic Framework: Externalities and the Social Cost of Carbon

A core principle in the economics of climate change is the idea of a negative externality, where the cost of emissions is not incorporated into the market price of goods and services. The misallocation of costs by the market result in an overproduction of emissions, and underinvestment in cleaner technologies.[1,2] Economists have worked to develop the concept of the Social Cost of Carbon (SCC) to address this issue, which is based on an attempt to quantify the monetary value of the damages caused by emitting one more ton of carbon dioxide.

The Social Cost of Carbon

The SCC is an essential mechanism for policy evaluation and is widely viewed as the “gold standard” for cost-benefit analysis for climate policy. The SCC is the present value for the future damages incurred from an additional ton of carbon dioxide emissions released today. The SCC is derived from sophisticated Integrated Assessment Models (IAMs) like dynamic integrated model of climate and economy (DICE), framework for uncertainty, negotiation, and distribution (FUND), and policy analysis of the greenhouse effect (PAGE) that model GDP growth, greenhouse gas concentrations, climate impacts, and eventual damages in order to quantify global damages. One major parameter in all these models that is contested is the discount rate. There is a strong inverse relationship between discount rate and SCC, which is intuitive: a higher discount rate places most value on economic outcomes that are nearer in time to today, and very little or no value on damages that occur progressively into the future, and thus has a low SCC. In a model with a lower discount rate, more value is placed on well-being at a given point in time, and thus you would arrive at a much higher SCC, creating a better economic case for immediate and aggressive climate action.[3,4] The question of what discount rate reflects the appropriate intergenerational equity is as much about ethics as it is about technical specification.

Table 1 demonstrates the considerable variability in SCC estimates, and the considerable sensitivity to model choice, but more importantly to the discount rate. Estimates are significantly higher using lower discount rates, allowing future damages to weigh more heavily on SCC values. The values reported by the Interagency Working Group for calculating SCC are averages across many models.

Statistical Studies and Empirical Evidence

Aside from theoretical modeling, there have been an increasing number of empirical studies that take

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advantage of statistical methodologies to estimate climate change's economic consequences based on historical data. Many of these studies conduct econometric analyses to then determine whether there is a causal influence of temperature anomalies on macroeconomic outcomes.

Researchers have leveraged large panel datasets on multiple countries or regions over several decades and run regressions to disentangle the weather variable from GDP growth, agricultural output, labor productivity, and other metrics from which estimates of long-term climate change influences can be calculated.[5,6]

Research indicates that persistent deviations from historical temperature norms have a meaningful, and usually non-linear negative influence on economic growth. Furthermore, lower-income nations, as well as agricultural and manufacturing sectors, are vulnerable to the detrimental long-term economic factors that emerge from climate change.[7,8] For example, Johnston[8] ran regressions indicating that a 1°C increase of average annual temperature above a historical average measure as a specific percentage decrease in pa GDP per capita, as summarized in Table 2 and Figures 1 and 2.

Table 1 | Comparison of SCC estimates from different economic models

Model Name	Discount Rate	SCC Estimate ($/t$CO_2$)
Dynamic Integrated model of Climate and Economy (DICE)	3%	$24 (2015 estimate)
Climate Framework for Uncertainty, Negotiation, and Distribution (FUND)	3%	$24 (2015 estimate)
Policy Analysis of the Greenhouse Effect (PAGE)	3%	$24 (2015 estimate)
U.S. Interagency Working Group (IWG) Average	5%	$7 (2015 estimate)
U.S. Interagency Working Group (IWG) Average	2.5%	$41 (2015 estimate)
EPA Draft (2022)	3%	$190

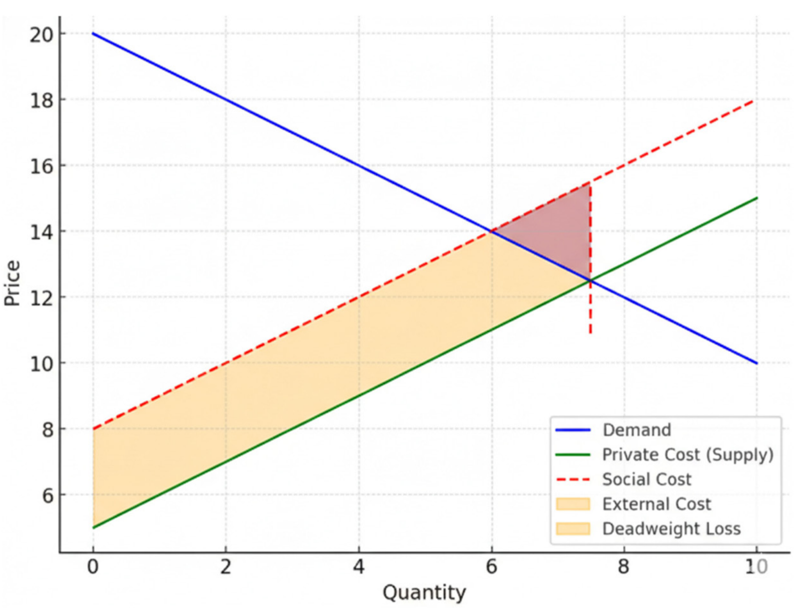

Fig 1 | Demand curve, private and social cost curves, cost gap, and the deadweight loss from the market failure

Policy Instruments for Mitigation

Policymakers have a variety of options for internalizing the external costs of carbon. The decisions policymakers make about which instruments to use and how to design them are critical for the instruments' effectiveness and political viability.

Carbon Pricing Mechanisms

These policies seek to create pay-for pollution, which make the polluter responsible for the social and environmental costs of their actions, resolving the market failure. A carbon tax is just a charge per ton of carbon in fossil fuels that provides a very clear continuous charge on fossil fuel usage, and allows for a very clear and stable price signal or carbon price that gives the incentive for firms and consumers to reduce their emissions going forward. Carbon taxes are often praised for clarity and simplicity, and also a further benefit of being a revenue generator, to fund green activities or for direct payments to their citizens.[9–13] However, the political problem often arises that for a domestic government to impose a unilateral carbon tax on firms in their jurisdiction creates legitimacy and fairness complications when the rest of the "world" does not set the same tax, it provides an unlevel playing field for firms seeking to compete in global markets.[14–16] This would be specifically referred to as a "carbon leakage" problem. Cap-and-trade systems provide another potential market-based approach, a government-imposed limit or cap defines the upper limit of emissions allowed from a sector of the economy. Firms then receive or can purchase tradable allowances. The allowance market traded price may fluctuate based on their carbon equivalency, in contrast to carbon taxes having fixed rates per ton carbon. The clustered market price of energy provided at lower emissions per unit, creates grants firms a dynamic, flexible and ongoing incentive to reduce lower they can get their emissions into absolute certainty on the total emission reductions being undertaken or achieved dependent of the fluctuating traded price of emissions allowances per carbon equivalency.[17,18] Important examples include the European Union's Emissions Trading Scheme (EU ETS) and several regional programs in Canada as depicted below (Table 3).[19,20]

Subsidies and Direct Public Investment

While carbon pricing is intended to punish emissions, subsidies and direct public investment support low-carbon activities and technologies by creating a reward structure. Green subsidies, such as feed-in tariffs for renewable electricity generation, production tax credits or tax credits for purchasers of electric vehicles, are designed to stimulate the adoption of clean technologies by making them more economically competitive with fossil fuels.[21,22] Government support is also critical when technologies rely on public investment to solve market failure related to innovation. The risk or cost associated with fundamental research and development (R&D) new clean technology very

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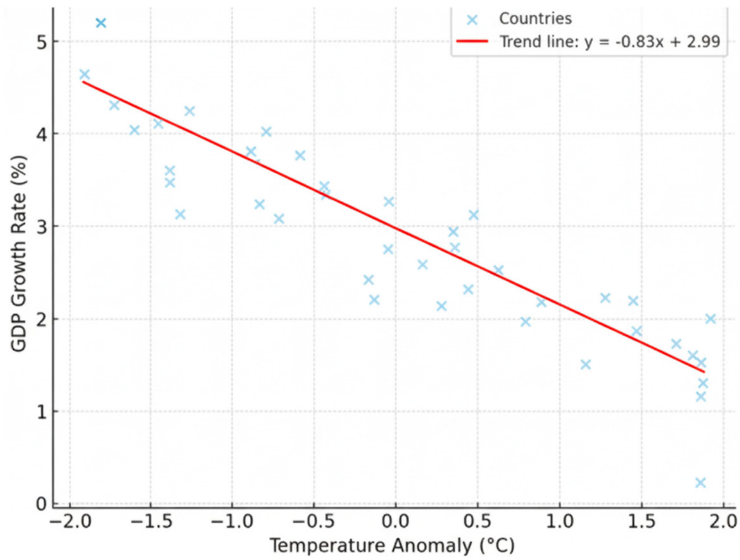

Fig 2 | Scatter plot of temperature anomalies versus GDP growth

Table 2 | Regression analysis of temperature anomalies on GDP per capita

Independent Variable	Estimated Coefficient Standard Error	P-value
Annual Temperature Anomaly (°C) −0.015	0.003	‹0.01
Annual Precipitation Anomaly (mm) −0.002	0.001	‹0.05

often exceeds what private firms (undoubtedly risk adverse) are prepared to assume. Through R&D, governments can stimulate a green industrial revolution that produces public goods for the benefit of the entire economy.[23,24] Moreover, it tends to be more politically palatable to support programs or subsidies as an investment in the economy and jobs, than it is to raise taxes.

Barriers to Action: the Political Economy of Climate Change

Despite the economic rationale and the existence of a wide array of policy tools, the implementation of effective climate policy faces significant hurdles.

The Time Horizon Mismatch

This problem is fundamentally about the immediate, concentrated costs of climate policy vs. the long-term, diffuse benefits. In the case of a carbon tax, we see immediate increases in gasoline and electricity prices that bring immediate political pushback and anger from voters. While the benefits an individual might experience from a more stable climate or from avoided future damages may not occur for many decades and are shared by everyone, this gives an elected official a powerful reason to defer or to dilute action on climate in favor of short-term political stability. Economists have analogized this to hyperbolic discounting -our behavioral bias to overvalue immediate rewards and costs, relative to their future alternative.

The Collective Action Problem

Climate change is a textbook case of a global public goods dilemma: the benefits of stability of the climate system are non-excludable and non-rivalrous.[25,26] This allows for the "free-rider problem" where, once again, it is rational for each nation to wait for other nations to bear the costs of emissions reductions while finding themselves benefitting for free from a cooler planet.[27,28] International agreements, like the Paris Agreement, aim to partially ameliorate the free-rider problem through voluntary commitments (Nationally Determined Contributions or NDCs), agreed to with transparency and peer pressure as enforcement mechanisms. However, there are no strong enforcement mechanisms, and the political and economic incentives to free-ride are strong, thus weakening the global agreement as a whole.[26,29,30]

Vested Interests and Lobbying

The status quo is supported by strong and powerful interests who have a vested interest in fossil fuel use. For example, the fossil fuel industry and its proxy businesses lobby for policies that target and seek to influence public opinion, promote laws to stymie climate policy.[31,32] The political effects of this lobbying create a large obstacle to change leading to gridlock or weak measures. In addition, the "incumbency effect" refers

Table 3 | National carbon tax vs. regional Cap-and-trade systems

Metric	Canadian Carbon Tax	European Union Emissions Trading System (EU ETS)
Policy Type	Carbon Tax Applies to most provinces and territories.	Cap-and-Trade (Emissions Trading)
Scope	Covers a broad range of fuels and emissions from industrial facilities, with a separate fuel charge and an output-based pricing system for large emitters.	The largest carbon market in the world, covering approximately 40% of the EU's greenhouse gas emissions. It includes power stations, industrial plants, and intra-European aviation.
Price/Allowance Mechanism	A direct tax rate on the carbon content of fuels, with the price set to increase annually. This provides price certainty for businesses and consumers.	A cap on total emissions is set and decreases over time. Companies receive or buy allowances, and the price is determined by the market supply and demand for these allowances, leading to price volatility.
Emissions Reduction Performance	Estimated to be a key driver in Canada meeting its 2030 climate targets. However, the effectiveness is still subject to ongoing debate and depends on the specific price level and how revenues are recycled.	The EU ETS has successfully reduced emissions from covered sectors by over 40% since its introduction in 2005, making it a powerful tool for decarbonization.

to the economies dependent on fossil fuel infrastructure and employment that are as a matter of policy reluctant to change.[33,34] A green economy and climate policies incur costs to existing jobs and business models, and hence it engenders considerable opposition that cannot be dismissed but instead requires a focus on just transition polices and a strategic approach to change (Figure 3).[35]

Bridging the Gap: Integrated Policy Solutions

To overcome these barriers, policymakers must design integrated solutions that address economic, political, and social considerations simultaneously.

Carbon Dividend and Revenue Recycling

The major political obstacle to a carbon tax is its potential for regressivity and the effect of the tax on low-income households. A carbon dividend and revenue recycling approach directly addresses regressivity. In a revenue-neutral carbon tax all of the revenue associated with the carbon tax is returned to the citizens, typically through equal rationing in the form of a check per individual. This approach is more publicly equitable and politically acceptable. By the government putting cash into people's hands the economic effects of rising energy prices are muted but the price signal allows businesses and consumers to decide to make a change to their carbon footprint.[36,37] This reframes the policy as a fair and market-based approach from a punitive tax.[10,11]

Strategic Investment and Industrial Policy

Aside from market corrections, government involvement is a necessary step in process of technological innovation that accompanies transition. This is essentially the aim of green industrial policy, a proactive approach to promoting new clean industries and technologies. Instead of waiting for the market's eventual course of correction, governments can overcome the market failure of innovation by funding fundamental R&D, financing early-stage capital, and generating a predictable policy landscape to demonstrate long-term commitment. This could be direct public investments in these types of projects including smart grid infrastructure, battery manufacturing, and hydrogen production. Ultimately this strategy changes the political frame from focusing on the costs of taking action on climate to focusing on the economic opportunities and employment creation of a new green economy.[35,38–41]

International Cooperation and Border Carbon Adjustments

The collective action dilemma and carbon leakage, where industries shift to jurisdictions with lower

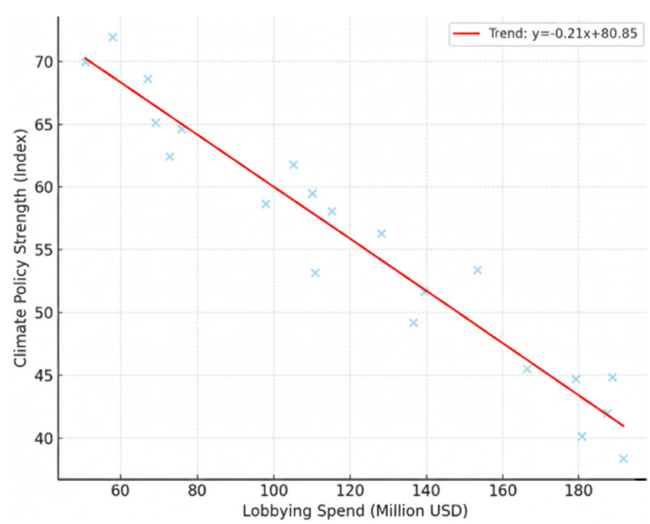

Fig 3 | Breakdown of global GHG emissions by sector and higher fossil fuel lobbying vs. weaker climate policy

Table 4 | Economic impacts of a carbon tax vs. a cap-and-trade sSystem

Metric	Carbon Tax	Cap-and-Trade
Emissions Certainty	Variable; emissions outcome depends on the price elasticity of demand for carbon-intensive goods.	High; the system provides a hard cap on total emissions, guaranteeing a specific reduction target.
Price Certainty	High; the tax rate is set and increases predictably over time.	Variable; the price of allowances is determined by market forces, leading to price volatility.
Administrative Complexity	Relatively low; the tax can be integrated into existing tax structures.	High; requires a robust system for monitoring emissions, distributing allowances, and operating a trading market.
Political Feasibility	Often faces strong political opposition due to its direct and visible costs to consumers.	Can be more politically palatable, as the price is less direct and often seen as a market solution, but the complexity can be a hurdle for public understanding.

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environmental regulations, are significant barriers to global climate agreement. Border Carbon Adjustments (BCAs) would help mitigate carbon leakage by applying a tariff to goods imported from countries that do not have a comparable carbon price. The BCA calculates how much carbon is embedded in a product, and then charges a tariff equivalent to what the domestic producer would have to pay. The major functions of a BCA are two-fold: it insulates domestic industries from foreign competitors which would otherwise have a cost advantage; and it provides a strong economic driver for other countries to develop their own climate policies to avoid the imposition of the BCA. The European Union's Carbon Border Adjustment Mechanism (CBAM) is one of the most visible world examples of a BCA (Table 4).[40,42,43]

Conclusion

The disparity between scientific consensus and climate change policy is administration failure, not science failure. The difference can be closed by internalizing the real costs of carbon, and by creating policies that are environmentally effective and politically palatable. A mix of market mechanisms, sensible public investment and effective international partnership is needed to close the gap. Moving forward requires us to shift from a reactive posture to proactive and integrated action in order to provide sustainable, attractive, and equitable futures.[41,44–46]

Recent economic literature highlights both the limitations of cost-benefit analysis and the central role of political economy in formulating viable climate policies.[15,16,44–47]

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