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Significant Developments in the Field of Environmental and Energy Economics

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Abstract

Through a systematic literature review (SLR) of 36 peer-reviewed journal papers in the field of environmental and energy economics and policy, this paper explains the welfare significance and equality issues connected to addressing climate change, the role of taxation and cap-and-trade, the formulation of discount rates, the analysis of existing policy effects, the role of government, the impact of technological innovation, the analysis and potential impact of human behavior, as well as the non-market valuation. This systematic literature review combs existing research on the scope of climate change, and reflects the impact of society, government, enterprises, and the public on climate change. In addition, I will conduct an in-depth discussion and analysis of some findings, and present ideas for further and more comprehensive future research that could guide policy solutions to climate change.

Keywords

Environmental and Energy Economics and Policy, Climate Change, Human Behavior

1. Introduction

Recently, society has paid more and more attention to the issue of climate change. Alleviating, improving, and even solving the problem of climate change is not only a paper agreement but also the goal of a community with a shared future for mankind. As many of you may know, the Paris Agreement, which was signed in 2016, had a long-term temperature target that ideally limits the rise in global average temperature to well below 1.5˚C (2.7˚F). This is indeed beneficial to human beings to solve the problem of climate change, but global warming is only part of the problem of climate change, not the whole.

The problem of climate change is a very broad concept, including sea level rise, food production decline, species extinction, human health, and so on. They

are too larger themes to attract enough attention from the public. After all, ordinary people may be the closest to the problem of climate change by replacing their natural gas stoves at home with induction cookers. So here are some real examples that have happened in recent years. In September 2021, there was snowfall in Africa, even accompanied by hail; in the summer of 2022, compared with the same period in previous years, the average temperature in China was 3 to 5 degrees higher. In addition, according to some research reports, which would be discussed in the following section of this article, climate change has seriously endangered human life expectancy.

This article will take the harm of climate change to human beings as the starting point, review and discuss some policies and attempts to improve and solve the problem of climate change, and conduct in-depth discussions on some viewpoints, in order to provide guidance and suggestions for policy improvement and global response to climate change.

This article will include ten sections. Section I is the introduction above. Section II will introduce the methodology of this article. Section III will discuss three papers that are related to the importance of research on climate change. Section IV will highlight the implications of addressing climate change in terms of equity via five papers. Section V will be extended from equity to discuss the formulation of various tax policies and cap-and-trade, which includes seven papers. Section VI will explain how the discount rate behaves in policy by discussing three papers. Section VII will be related to the performance of the government and the outcomes of the policies through ten papers. Section VIII will show the contribution or the potential contributions of technological innovation to the solutions to climate change. Section IX will provide more details on the analysis of human behavior, which is also mentioned in the other parts, but isn't the main topic. Section X will discuss two approaches to making a non-market valuation. Section XI will be the conclusion.

2. Methodology

This article uses a systematic literature review (SLR) method to retrieve papers from the past 60 years, aiming to help the audiences get a good understanding of the field and topics of importance that have influenced environmental and climate policies today.

This review is centered on the seminal findings in environmental economics, spanning from the very basics of the economic theory of externalities and the Coase Theorem to more advanced theoretical/empirical topics in non-market valuation, to applied topics such as cost-effective policy instruments for climate change. The key research areas include Externalities, Public Goods, and the Discount Rate; Taxes, Cap-and-Trade, and Instrument Choice; Technological Change; Distributional Issues; Environmental Health; Non-Market Valuation; and Behavioral Economics and Environmental Policy. This article selects the most important and most relevant articles in each field, as follows (**Table 1**).

Table 1. Systematic literature review.

No.	Area	Paper	Content
1	Externalities, Public Goods, and the Discount Rate	Muller, Nicholas Z. and Robert Mendelsohn (2009)	Policy-marginal pollution damages
2	Externalities, Public Goods, and the Discount Rate	Coase, Ronald H. (1960)	Policy-pricing system
3	Externalities, Public Goods, and the Discount Rate	Jacobsen, Mark R., Christopher R. Knittel, James M. Sallee and Arthur A. van Benthem (2016)	Policy-energy efficiency policy
4	Externalities, Public Goods, and the Discount Rate	Ostrom, Elinor (2010)	Government
5	Externalities, Public Goods, and the Discount Rate	Weitzman, Martin (2001)	Discount rate
6	Externalities, Public Goods, and the Discount Rate	Arrow, et al. (2014)	Declining discount rate
7	Externalities, Public Goods, and the Discount Rate	Borenstein, Severin (2012)	Policy
8	Taxes, Cap-and-Trade, and Instrument Choice	Goulder, L.H. (1994)	"Double dividend" effect
9	Taxes, Cap-and-Trade, and Instrument Choice	Goulder, Lawrence H. and Roberton C. Williams III. (2003)	Tax
10	Taxes, Cap-and-Trade, and Instrument Choice	Gilbert E. Metcalf (2010)	Cap-and-trade and taxes
11	Taxes, Cap-and-Trade, and Instrument Choice	Schmalensee, Richard and Robert Stavins (2015)	Cap-and-trade and taxes; emissions trading systems
12	Taxes, Cap-and-Trade, and Instrument Choice	Weitzman, Martin (1974)	Price vs Quantity
13	Taxes, Cap-and-Trade, and Instrument Choice	Kling, Catherine and Jonathan Rubin (1997)	Discounting Rate
14	Taxes, Cap-and-Trade, and Instrument Choice	Fowlie, M. & Perloff, J.M. (2013)	Cap-and-trade
15	Taxes, Cap-and-Trade, and Instrument Choice	Greenstone, Michael (2002)	Policy-impacts of regulations
16	Taxes, Cap-and-Trade, and Instrument Choice	W. Reed Walker (2013)	Policy-impacts of regulations
17	Taxes, Cap-and-Trade, and Instrument Choice	Fabra, Natalia and Mar Reguant (2014)	Policy-effects of regulations
18	Taxes, Cap-and-Trade, and Instrument Choice	Aldy, Joseph E. and William A. Pizer (2015)	Distributional equity
19	Taxes, Cap-and-Trade, and Instrument Choice	Cicala, Steve (2015)	Deregulation
20	Taxes, Cap-and-Trade, and Instrument Choice	Fowlie, M.L. (2009)	Regulation-real-world market
21	Taxes, Cap-and-Trade, and Instrument Choice	Stavins, Robert N. (1996)	Price vs Quantity
22	Technological Change	Newell, Richard G., Adam B. Jaffe and Robert N. Stavins (1999)	Hick's hypothesis; technological change
23	Technological Change	Popp, David (2002)	Hick's hypothesis; technological change
24	Distributional Issues	Levinson, Arik (2018)	Distributional equity
25	Distributional Issues	Borenstein, S. and L.W. Davis (2015)	Distributional equity
26	Distributional Issues	Lucas W. Davis and Lutz Kilian (2011)	Distributional equity
27	Distributional Issues	Borenstein, Severin (2012)	Distributional equality
28	Environmental Health	Chay, Kenneth Y. and Michael Greenstone (2003)	Public health; importance

Continued

29	Environmental Health	Chen, Y., Ebenstein, A., Greenstone, M. & Li, H. (2013)	Public health; importance
30	Environmental Health	Burgess, R., Deschenes, O., Donaldson, D. & Greenstone, M. (2017)	Public health; importance
31	Non-Market Valuation	Carson, Richard T. (2012)	Non-market valuation
32	Non-Market Valuation	Viscusi, W. Kip and Joseph E. Aldy (2003)	Non-market valuation
33	Non-Market Valuation	Diamond, P.A. & Hausman, J.A. (1994) and the later Hausman, J. (2012)	Non-market valuation
34	Non-Market Valuation	Hausman, J. (2012)	Non-market valuation
35	Behavioral Economics and Environmental Policy	Allcott, H. (2011)	Human Behavior
36	Behavioral Economics and Environmental Policy	Allcott, H. & Greenstone, M. (2012)	Human Behavior

By sorting out the key content of these 36 papers, this paper divides them into six categories, including Importance on Climate Change Research, Distributional Equality, Tax & Cap-and-Trade, Discounting Rate, Government & Policy, Technological Innovation, Human Behavior Analysis, and Non-market Valuation.

3. Importance on Climate Change Research

As mentioned in section I, the problem of climate change will affect people's life expectancy. In this section, I will discuss the impact of climate change on human health through the discussion of three papers, which reflects the significance of the research on the climate change problem.

Chen, Y., Ebenstein, A., Greenstone, M. & Li, H. (2013) examined the health consequences of these extraordinary pollution levels by exploiting China's Huai River policy and found that greatly increases total suspended particulates (TSPs) air pollution is causing the 500 million residents of Northern China to lose more than 2.5 billion life years of life expectancy, which means average lose in life expectancy is 5 years per person. In the process of digesting the shocking results, I also realized the importance of studying the consequences of climate change brought about by a policy, which should also be predicted when the policy is formulated. Of course, this has certain difficulties.

Heat pump heating may be a good substitute for coal heating, but it has high requirements for building design and high initial assembly costs, which are the main problems in promoting heat pump heating at present. If the government provides relevant subsidies here, it may benefit the health of the people.

Burgess, R., Deschenes, O., Donaldson, D. & Greenstone, M. (2017) examined health impacts in a developing country (India) and provides evidence that damage is heterogeneous even within the same country, which hot days lead to substantial increases in mortality in rural but not urban India. I would like to say that equitable transition is also important here, which would be beneficial to the developing country and rural areas, and I will discuss more in Section III. They

also found the rural death effects are driven by hot days in the growing season which reduces productivity and wages in agriculture. Thus, the expansion of bank branches into rural India helped to mitigate these effects. The logic behind this result shows the economy has an influence on human health, so I assume other economic actions would have the same or better effect. According to the actual situation, different countries can set different approaches to solving the same problem as India.

For the implication of this paper, which shows the negative effect on the life expectancy of the US population, I would like to emphasize that climate change is a global problem, whether in developed or developing countries, in urban or rural areas, people's health will be affected, and to deal with global problems, we need more countries to join in and formulate relevant policies so that we can solve the problem together.

Chay, Kenneth Y. and Michael Greenstone (2003) estimated the impact of total suspended particulates (TSPs) on infant mortality and found that 2500 fewer infants died from 1980-1982 than would have in the absence of the TSPs reductions. The analysis also revealed nonlinear effects of TSPs pollution and greater sensitivity of black infant mortality at the county level.

This again underscores the impact of equity in addressing climate change. The study also shows the impact of climate change on infants, which means that when a person comes into the world, there is a risk of being robbed of their health and even their lives by related problems. This study has certain limitations. In my opinion, it is possible that in the 1981-1982 recession, the pregnant woman would have more mental pressure, behavioral changes, or something else that would have bad effects on the infant which lead this article to underestimate the effects of air pollution.

These three articles analyzed the impact of climate change on human life expectancy from different perspectives, thus highlighting the importance of research in this area.

4. Distributional Equality

Through five papers, this section will continue the previous section with further discussion on the equity of addressing climate change. This section will discuss the possible beneficiaries of some policies from an economic point of view, rather than discussing longevity.

In the paper of Lucas W. Davis and Lutz Kilian (2011), the finding is when there is no secondary market, the random allocation is inefficient because it does not allocate goods to buyers with the highest willingness to pay. And the main contribution of this paper is when there is a shortage (demand > supply), welfare losses come from 1) demand not being met, and 2) limited supplies may not be meeting the demand of consumers who value the supply most. Thus, in addition to traditional deadweight losses, policymakers should carefully consider the allocation costs of price regulation when conducting an ex-ante economic analysis

of regulatory reform. One outstanding strength of this paper is that it is wise to compare the actual data during the period 1950-2000 with the predicted data based on the choice of consumers in an unconstrained world.

Another paper using natural gas to provide evidence on distributional equality is by Borenstein, Severin and Lucas W. Davis (2012). They found that the correlation between household income and gas consumption is indeed positive, but surprisingly weak, so the current rate schedule is only a modest improvement. Even a modest energy aid package would be enough to offset the distributional impact of tariff rebalancing on most low-income households. Policymakers must keep in mind the trade-off between efficiency and fairness when implementing an interest rate structure. But the data set the author chose might be not representative because it comes from a survey, which would have some reasons or factors that influence the effectiveness of the result.

Levinson, Arik (2018) also theoretically and practically demonstrates that energy efficiency standards are more regressive than energy taxes, not less. This paper examines the behavior of the poor and the rich, which shows that wealthier households will buy more energy efficiency and more energy, which leads to different effects on these two people. A tax on inefficient appliances would be more regressive than a tax on energy. One key insight from this paper is that, by assuming that welfare losses are proportional to "before-tax" consumption, any change in relative "after-tax" consumption is negligible, i.e. we no longer worry about how taxes might change purchasing decisions.

Borenstein, S. and L.W. Davis (2015) explained the regressive nature of clean energy tax credits with policy design features (e.g. eligibility; ability to claim credits; incentives to claim credits; refundability) by using tax return data. When analyzing something or some data, it is hard but necessary to find the key factors that have a direct or indirect impact on the results/fact, but this paper did well. Thus, it shows a surprising result that it seems some policy or standard would be more beneficial for high-income households. The policy, in my opinion, should try to narrow the gap between low-income households and high-income households, at least, it should be "equal cost" for both. Thus, it is important for policymakers to make an equitable energy transition for the world, maybe starting from some regions.

As the papers mentioned above, Aldy, Joseph E. and William A. Pizer (2015) also used tax to discuss distributional equity, but not using different income levels of people, but different development levels of countries, which evaluates the hypothesis that unilateral domestic climate change mitigation policy would impose significant economic costs on carbon-intensive industries, resulting in declining output and increasing net imports. Even though there are weaknesses in their analysis, such as they clearly know the disadvantage of the analysis that either a lack of substitutability with foreign goods or a lack of additional global capacity over the horizon they examine, they have risen to the discussion of international fairness. Most developing countries are energy-intensive, so when

addressing climate change, it is also a very important proposition to balance developing countries and developed countries, that is, how to balance the economies of developing countries and carbon emissions.

The above five papers focus on the discussion of equity. People from different income classes to countries from different levels of development are facing similar problems. Thus, it is not a problem for some people, but a problem all over the world. It is not difficult to find that the main tool of the above discussion is taxation. We will discuss this further in the next section.

5. Tax & Cap-and-Trade

After discussing the importance of addressing climate change and the fairness of achieving its goals, we will continue our discussion of taxation from the previous section. Economists and policymakers use taxes and cap-and-trade as two major market-based policy instruments to reduce environmental pollution and GHG emissions. This section will discuss these two instruments in detail.

Weitzman, Martin (1974) discussed what is the best way/mode to implement either prices or quantities. Under uncertainty about costs, the relative slopes of the marginal benefit and marginal cost curves determine whether price instruments are preferred to quantity restrictions. If the expected marginal benefits from reducing emissions are flat compared to the cost of abatement, then a price control is preferred. Conversely, if the marginal benefit curve is steeper, then quantity control is preferred. In some situations, "mixed" price-quantity modes may give the best results. Benefit uncertainty did not matter under Weitzman, only cost uncertainty did.

Unlike Weitzman who assumed that uncertainties across MB and MC are independent, Stavins, Robert N. (1996) discussed cases where they could be correlated and indeed, found different conclusions, which shows that at reasonable values of the relevant parameters, the traditional identification of price instruments will be reversed in favor of quantity instruments, and the opposite reversal—from choosing a quantity instrument to a price instrument—seems unlikely to happen. And one key insight here is that when we think about benefits and costs, we need to strictly consider social benefits and social costs, which means that the whole point of introducing a market-based instrument is to address externalities—all non-market benefits and costs must be internalized.

Schmalensee, Richard and Robert Stavins (2015) examined the design and performance of seven of the most prominent emissions trading systems that have been implemented over the past 30 years—systems that are particularly important environmentally and/or economically and the performance of which has been documented, and asked what lessons were learned from them. Their key findings are that Market-based instruments (cap-and-trade and taxes) are designed to be cost-effective and that the more the cost of abating pollution differs among sources, the greater the cost savings a market-based system has. Actually, in the real world, most countries do not have the institutional strength to im-

plement such programs. Based on these studies analyzing existing programs, each country can establish its own programs, and even connect these systems into one, which is a favorable development direction for the future.

Gilbert E. Metcalf (2010) proposes a regression work to examine on how the tax code (user cost rather than the effective tax rate) affects investment in energy capital. The key finding is that Wind investment is strongly responsive to changes in tax policy. However, just choosing one resource (wind here) power generator will affect the results. Thus, this conclusion is informative, but imprecise.

Fowlie, M. & Perloff, J.M. (2013) exploited the random assignment of firms to different permit allocation cycles in Southern California's RECLAIM Program to test the independence of firm's initial permit allocations and emissions, which challenged a more fundamental understanding of cap-and-trade, and the key finding is that initial allocation should not sway the outcome, nor violate the realization cost-effectiveness condition. One of the advantages of this paper is trying to find a way to omit variations of data, for example purging the estimates of all permanent plant characteristics that determine both emissions and initial permit allocations, which is an important econometric tool to address endogeneity.

This paper already used reasonable data, but the result is also imprecise, and it may be needed to get more data from other case studies to do an analysis. It also reflects one piece of information: it is imperfect for the current cap-and-trade program.

Goulder, L.H. (1994) articulated different notions of "double dividend" effect (DDE), a tax that is different from a cap-and-trade system in that it guarantees revenue for the government, and examined the theoretical and empirical evidence for each. In addition, it draws connections between the double dividend issue and principles of optimal environmental taxation in a second-best setting. The key insight here is that environmental taxes can have greater benefits beyond correcting externalities. If taxes collected from carbon can be used to reduce income tax, since the government only needs a fixed amount of revenue to operate, there is a benefit from cutting carbon emissions to happen.

Goulder, Lawrence H. and Roberton C. Williams III (2003) talked about potential general equilibrium effects in estimating tax burden and found that, in typical cases, the simple "excess burden triangle" formula greatly underestimates the excess burden of goods tax. The practicality of the study lies in that the welfare implications of a tax are evaluated through the utility of the consumer, for whom utility changes because a tax changes the price of the good he/she consumes and his/her real income, which means as goods become more expensive we become poorer in real terms.

From the selection of two major market-based policy instruments, the advantages and disadvantages of the current system, and the actual impact of taxation on us, the above seven articles discuss these two tools, give some suggestions to tax policymakers, and propose the suggestion of establishment and even improvement for the cap-and-trade program.

6. Discounting Rate

As can be seen from the discussion in the previous section, no matter what kind of instruments the policymakers choose, it is closely related to policy making. Before discussing the relevant policies formally, I will discuss discounting rates through three papers in this section, which is often at the very center of policy discussions, and usually carries ethical and existential thinking.

Kling, Catherine and Jonathan Rubin (1997) examined the role of banking in the permit market and explained the difference in incentives behind private vs public decision-making in terms of banking/borrowing decisions by using a simple optimal control model. The key finding is that a private solution is not optimal; a discount rate is a solution, which means that, in reality, firms do not anticipate gains from abatement unless strong market incentives exist. This paper highlights the importance of policies, especially discount rates, in cap-and-trade systems, to enable correcting environmental externalities.

By incorporating the probability distribution directly into the analysis, Weitzman, Martin (2001) rationalizes declining discount rates through a statistical model to resolve the perennial dilemma of being uncertain about what discount rate to use in cost-benefit analysis and found that even if every individual believes in a constant discount rate, the widespread opinion on what it should be makes the effective social discount rate decline significantly over time. One of the advantages is that this paper just proposes an assumption of an inconstant discount rate, so the authors use the method as simple as possible, which is much clearer to support their assumption. But just using the opinions of economists has limitations on policy analysis. Because one "type" person, namely one professional, maybe have "stereotyped thinking", which will lead to results similar.

Arrow et al 2014 focused on examining whether the principles, which should be used to determine the rates at which to discount the costs and benefits of regulatory programs, suggest that project evaluation should use a declining discount rate (DDR) schedule or a constant exponential rate, and found that the arguments in favor of a DDR are compelling and thus merit serious consideration by regulatory agencies in the United States.

The papers discussed in this section demonstrate the importance of discounting rates, and I believe that everyone has a preliminary understanding of policymaking. I will discuss the details of some policies to solve climate change in the next section.

7. Government & Policy

As Kling et al discussed in the paper, the private solution is not optimal. Thus, in most situations, the government uses policies as tools to set standards and solve the problems of climate change. In this section, I will discuss ten papers to provide more details and insight into the past and current policies, identify the government's role in policymaking, and offer some suggestions for future policy-

making.

Fowlie, M.L. (2009) examined the "real-world" market that policymakers often aim to fix, which is generally incompletely regulated and imperfectly competitive. Her finding that cap-and-trade and emissions tax can be cost-effective is largely based on the "baseline" that apart from the existence of pollution externalities, the market is largely efficient. The key intuitions are that if the product market is more competitive, a given firm's market share will be more significantly affected by a regulation-induced change in relative marginal operating costs, leading to more leakage; if exempt producers are dirtier than their regulated counterparts, it is possible for emissions leakage to exceed the reduction in emissions achieved by regulated firms; introduction of environmental regulation into a Cournot oligopoly changed firm's relative operating costs and redistributes market share towards firms whose relative costs have decreased; if the firms exempt are cleaner, this reallocation may result in lower overall emissions when participation is incomplete.

Greenstone, Michael (2002) focused on the impacts of regulations on polluting entities in regulated zones, found that emitters of pollutants in counties designated non-attainment under the Clean Air Act were subject to greater regulatory oversight, and, by controlling for the plant, industry by period, county by period fixed effects, found that the evidence of the negative impact of regulation on pollution-intensive industries. The data they chose allows for the identification of cross-sectional variation in these regulations and changes in counties' pollutant-specific regulatory status over time. But if they include the data of non-attainment counties, the result would be much more reasonable. That is, the result and fact lack a causal relationship, it also could be the result of other things, such as other policies.

W. Reed Walker (2013) focused on workers employed within the regulated sectors, which used linked worker-firm data in the United States to estimate the transitional costs associated with reallocating workers from newly regulated industries to other sectors of the economy in the context of new environmental regulations. He found that most of these costs are driven by nonemployment and lower earnings in future employment, highlighting the importance of longitudinal data for characterizing the costs and consequences of labor market adjustment. Relative to the estimated benefits of the 1990 CAAA, these one-time transitional costs are small, which is sometimes referred to as labor market friction.

Cicala, Steve (2015) examined the role of "deregulation" of electric utility companies, found that deregulation allows utilities that hold coal-fired power plants to significantly reduce the cost of acquiring coal as a production input, and explained that this cost reduction is more pronounced than utilities that hold natural gas-fired power plants is due to higher asymmetric information in coal procurement. Deregulation also leads to a shift towards out-of-state mines, as regulated plants may face a greater degree of regulatory capture. Information asymmetry, regulatory capture, and capital biases can all lead to serious dis-

tortions in purchasing decisions. The surprising finding here is that deregulation has a positive effect on cost reduction.

Fabra, Natalia and Mar Reguant (2014) also used the electricity market to examine how shocks to the input costs of electricity generation (e.g., carbon prices affecting electricity generation costs) are transmitted to wholesale electricity prices. Because electricity is auctioned at high frequencies in exchange for highly inelastic demand, companies have little incentive to adjust markups after cost shocks. High-frequency pricing makes it difficult to adapt perfectly to fluctuating costs and inelastic demand means that consumers wouldn't increase or reduce electricity prices after cost shocks. This paper also mentioned human behavior, which I believe is important—people may respond to changes (e.g. policies) differently, and data collected generally include responses from a variety of different response groups in the population. It's difficult to separate the actions of a certain type of human from the data—and will discuss more in Section VIII.

Muller, Nicholas Z. and Robert Mendelsohn (2009) argue that regulators can use new data on source-specific marginal damages to move the current market-based pollution policies from cost-effectiveness to efficiency. Even though this paper includes a discussion on human health and distributional equity, one of the key findings is that the marginal damages of emissions are especially high in large metropolitan areas compared to low-population rural areas, I classify it in this section to highlight the contribution of policies and policymakers. An efficient policy with exchange rates reflecting differing marginal damages has large welfare benefits. Such a policy would require a substantial increase in abatement in cities, especially large metropolitan areas.

In the paper of Jacobsen, Mark R., Christopher R. Knittel, James M. Sallee and Arthur A. van Benthem (2016), it shows when different products have different average life-cycle utilization, energy efficiency policies, which simply create explicit or implicit price incentives based on energy efficiency classes, are inherently imprecise. The authors believe that statistics from simple regressions of true externality on variables upon which policy is based have direct welfare interpretations. This paper took a good example that is close to our lives—how to tax secondhand smoke. Policies are not far from us but closely related to people's livelihoods. Only by studying these policies that are easy to understand, or "closer" to the people, the public would easily realize the importance of addressing climate change and understand the government uses the policies as a tool to solve problems, which are related to our benefits.

Coase, Ronald H. (1960) argues that when information and transaction costs are low, the market will produce an efficient solution to the problem of nuisances without regard to where the law places the liability for the nuisance. The key findings are that the main advantage of a pricing system is that it leads to the employment of factors in places where the value of the product yield is greatest and does so at least cost than alternative systems, and that when we assume zero transaction costs and a set of regularity conditions in economics, it does not matter who becomes liable for damages. Even though most references in this pa-

per are quoted from others' statements and real events, it fully embodies the divergence of private benefits and societal benefits, which is also the key dilemma to balancing the phasing out of coal and economic development.

The above papers have expounded the contribution and role of government or policies in addressing climate change, but Ostrom, Elinor (2010) believed that building trust and developing institutional rules that are well matched to the ecological systems being used are of central importance for solving social dilemmas. Humans have a more complex motivational structure and more capability to solve social dilemmas so the government should not be the only way to solve them, cooperating with local and regional officials, nongovernmental organizations, and local citizen groups would achieve better payoff results for each one. Indeed, there are many NGOs dedicated to acting as a link between society and government to help solve the problem of climate change, and we have seen their role that cannot be ignored.

Borenstein, Severin (2012) discussed the market and non-market valuations of electricity generation from renewable sources that affect its costs and benefits. On the one hand, subsidies to renewables have been a prevalent policy to address power sector externalities, and the most effective policy is to appropriately price these externalities. On the other hand, understanding the costs and benefits of these technologies in the context of modern power systems is critical if governments are to implement reasoned renewable energy generation policies. While discussing how governments can price those externalities, this paper proposes technology, which is also an important topic for addressing climate change, which we will discuss in detail in the next section.

In this section, we review many policies, whether they are proven effective or have drawbacks, all of which reflect the way countries are exploring their development. While the government fully demonstrates its importance, NGOs also play an important role. Policymaking is far from the masses, but policy implementation is closely related to us.

8. Technological Innovation

Technological innovation also plays an important role in solving the problem of climate change. Whether it is improving energy efficiency or upgrading technology to achieve energy transition, the implementation of relevant policies can achieve twice the result with half the effort. Hick's induced innovation hypothesis states that an increase in the relative price of energy will lead to technological change that will reduce the energy intensity of the economy. This section will discuss this hypothesis through two papers.

Newell, Richard G., Adam B. Jaffe and Robert N. Stavins (1999), which is the first paper to test the IIH on product costs and characteristics, and decompose the overall change in energy efficiency into overall technological change, directional technological change, and substitution between models of energy-using durables, found that the overall speed of innovation is independent of energy prices and regulations, while the direction of innovation is

responsive to changes in energy prices. Energy efficiency labels greatly improve responsiveness, but most efficiency improvements are autonomous. However, the data needed for the model in this paper are quite limited for many important products.

Using patent citations to construct a measure of the quality of the existing scientific knowledge base, Popp, David (2002) found that both energy prices and the quality of existing knowledge have strong and significant positive effects on innovation. The key intuition is that knowledge stock will play a significant role in inducing future innovation, together with energy prices and other determinants, but the usefulness of the knowledge will decay over time.

The papers in this section affirm the positive impact of technological innovation, but also extend that policymaking needs to consider the masses or consumers, as knowledge decays. So far, I have reviewed papers of 7 sections, many of which address the impact of human behavior, which I will discuss in detail in the next section.

9. Human Behavior Analysis

Human behavior analysis is the topic I am most interested in. On the one hand, it exists in policy formulation, market regulation, or other actions, and its influence cannot be avoided. On the other hand, current research does not have a practical way to effectively assess the impact of human behavior. That is to say, all the research on the existence of human behavior has no way to accurately judge what kind of impact it will bring. This section will examine behavioral patterns in environmental/ energy economics through two papers.

Allcott, H. (2011) on energy conservation looked at how non-price interventions could affect consumer decisions. Conventional economic theory states that choices can only be affected by financial incentives or price incentives. This paper shows that non-price information campaigns can also sway consumer behavior and could prove to be an effective alternative to government policy. One of the decisions being affected by non-price interventions is the sign in the street or any public area, such as "Save Water".

Allcott, H. & Greenstone, M. (2012) focused on the more general concept of the energy efficiency gap—the observation that certain energy efficiency improvements are financially rewarding but not adopted, which can only be explained by behavioral patterns inconsistent with economic theory. They found that even if the energy cost savings were known, energy efficiency investments often have other unobserved costs and benefits, making it difficult to assess welfare effects. This behavioral literature has become more important in the field in the past decade, as more experts suggest coupling government intervention with non-policy measures that elicit more responses from the public.

It is a good phenomenon that more and more studies are focusing on the study of human behavior. Some economists are starting to talk about non-market valuations, which I will discuss in the next section.

10. Non-Market Valuation

When we think about the benefits of environmental protection (or damages from environmental problems), we often think about health outcomes (we already know this can be quite important from previous weeks) and environmental utility (beauty to the eye, eco-diversity, etc.). This section will through two approaches—revealed preference models and stated preference models—to conduct a non-market valuation, which is to place a monetary value on things that are not traded on the market and with no market price.

Viscusi, W. Kip and Joseph E. Aldy (2003) did an excellent job introducing the concept as well as the methodology and data required to construct monetary estimates. It also provides a wide array of examples and compares the value of statistical life estimates across different cases. Their meta-analysis indicates an income elasticity of the value of a statistical life from about 0.5 to 0.6, which means that higher-income people tend to be willing to pay more to reduce equal risk. One interesting fact I found in this paper: individuals who engage in risky behaviors, such as cigarette smoking and driving without seatbelts, have lower implicit values for injury than those who do not engage in such behavior. But it could also be a tradeoff by choice, which means that nonsmokers receive a greater risk premium in their wages than smokers because the safety effect flattens smokers' offer curves enough to offset smokers' preferences for greater wages at higher risk levels.

Different from RPM, CV asks people directly how much they would be willing to pay to preserve an environmental good, or how much they are willing to accept to tolerate an environmental hazard. These responses are then translated into valuations of changes to the environment. Carson, Richard T. (2012) was a more basic introduction to Contingent Valuation methods and provides an overview of practices and weaknesses. The key finding is that contingent valuation is not perfect, but better than no valuation. Diamond, P.A. & Hausman, J.A. (1994), and the later Hausman, J. (2012) paper took on a more pessimistic approach to analyzing CV and reviewing key challenges/weaknesses inherent to the methodology and often beset in its implementation. However, in my opinion, even though we couldn't find the principle of human behavior, or we couldn't copy the principle of this case to another case, we will have the result one day. It is like a breakthrough—we couldn't predict it will be coming but maybe it will be there soon.

11. Conclusions & Suggestions

After reviewing 36 papers, I have the conclusions and suggestions as follows:

Climate change is a global problem, and its impact is underestimated.

Governments use policies as the key tool to improve and address climate change, but when making the policies, it is necessary to anticipate future consequences after implementing them. At present, the alternative to coal and electric heating is heat pump heating, but there are still some problems needed to be

solved, such as subsidies for the initial installation fee.

The same policy can have different or even opposite effects on people with different levels of income. Therefore, balancing the costs and benefits of different groups, and even balancing the costs and benefits of countries at different stages of development, is an important topic and the focus of the current debate.

It is imperfect for the current cap-and-trade programs. It is very important to improve them and assist countries that do not have the conditions to establish programs. If there are feasible means in the future to form a globally integrated program, it will be beneficial to balance countries' policies and help achieve global goals.

When conducting research, the selection and processing of data are important and can affect the accuracy of the results.

If there is a reasonable tax on emission reduction, other taxes will be reduced, which is a tangible economic benefit for everyone. Many policies are not very far from us, such as a tax on secondhand smoke. In addition to taxes, a discount rate is also an important tool for policymaking.

Policymakers often aim to fix "real world" markets, and deregulation has a positive effect on cost reduction.

An efficient policy with exchange rates reflecting differing marginal damages has large welfare benefits.

Governments are not the only means of tackling climate change, NGOs can also support us to achieve global goals, which may conduct campaigns through public welfare and other means. Through research on human behavior and non-market valuation, we are not difficult to find that it is one example of a human being affected by non-price interventions.

Technological innovation has a positive impact, but it also needs to consider the masses or consumers in policy-making, because knowledge would decay.

For future research priorities, I suggest deepening research on human behavior, which has far-reaching implications for policymaking and non-price interventions. I look forward to seeing better and more accurate models in the future.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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