The Effect of Climate Change Mitigating Policy on Electricity Prices

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1 Executive Summary

Climate Change has both immediate and long-term negative effects on both the envi ronment and the economy with some estimates calculating that for every ton of carbon humans emit into the atmosphere, we could see $900-$1500 in damage to economic growth.

- The business-as-usual approach to carbon emissions will result in significant damage to GDP and economic growth but carbon reduction approaches could mitigate this damage.
  - As economies industrialize, they reach a point along the environmental Kuznets curve where it becomes beneficial for them to begin reducing their emissions and both the United States at large, and many states, have reached this point.
  - However, political inaction at the international and national levels means that the most important players in the United States addressing the looming climate crisis are state and local legislators.
- State carbon emissions legislation is key to tackling climate change; however, a common refrain from those opposed to carbon mitigation policy is that the additional costs incurred by electrical utilities to meet the policy guidelines will be passed along to consumers in the form of higher electricity bills.
  - By applying a Chow test to two somewhat similar states, we saw there was a significant change in prices following the implementation of carbon policy in West Virginia.
  - When we looked at all states, there also appeared to be a significant increase in the price of electricity accompanying carbon policy implementation.
  - However, when we take into account variations in time and states that are outside of our model, including traditional drivers of electricity costs like fossil fuel costs and inflation, the increase in prices appears to decrease significantly meaning most of the increases in prices seen can be attributed to some other factor other than environmental policy.

  - There still remains a marginal increase in electricity prices attributed to pol icy implementation in our model, but the amount is a one-time increase of roughly 2.2% which when compared against the potential economic dam age climate change could cause is a modest price to pay.

- Based on these findings, we recommend that state policymakers implement some kind of carbon mitigation policy that includes measures such as price controls or tax incentives to offset the modest one-time increase in prices that could accom pany the implementation of the policy.

2 The Climate Crisis

In 2017 The Climate Science Special Report confirmed that the world was experiencing the warmest period in human history. The global annual air temperature average has increased by nearly 2 degrees. The United States is experiencing more heatwaves and fewer cold snaps, and temperatures are expected to continue to rise an additional 2.5 degrees by 2050 (Weubbles, 2017). A warming climate means more than rising tem peratures. Climate change also affects sea levels. Warmer temperatures cause glaciers to melt and seawater to expand. The average global sea level has risen by over 8 inches since 1880, with one-third of that change occurring in the last 20 years. By 2100 sea levels are projected to have risen by 12 inches from 2000 levels, putting millions of people at risk for severe coastal flooding (Lindsey, 2011). One of the main drivers of climate change is the emission of greenhouse gasses. Global atmospheric carbon dioxide levels are over 400 parts per million, a concentration that has not been reached for about 3 million years when both average sea level and average temperature were higher than current levels. The severity of these changes is largely dependent on the amount of greenhouse gasses that are emitted globally. Only by significantly reduc ing emissions could the increases in temperature and sea level be mitigated (Weubbles, 2017). How the United States responds to these issues will have lasting environmental and economic effects.

Anthropogenic climate change is not just going to take an unimaginable toll on the environment and many of the delicate ecosystems across the globe, but there will also be considerable economic impacts from our changing of the climate as well. Rising sea levels and a sharp increase in extremely deadly weather events will wreak havoc on the interconnected global supply chain damaging necessary infrastructure and dis placing millions of workers. Some macroeconomic estimates have hypothesized that if humanity were to continue along the “business-as-usual” trajectory where no carbon mitigation efforts are attempted, there could be a decrease in median GDP globally of almost 7.22% by 2100 with some countries seeing a much steeper drop; however, if we were to attempt the relatively modest mitigation targets set by the Paris Climate Ac cords, estimates show global GDP only decreased by a median of about 1.07% (Kahn, et al., 2019). Furthermore, economic analyses focused on the United States noted evi dence suggesting climate change will damage Gross State Product across all 50 states; decrease employment and labor productivity; and harm growth in sectors like agricul ture, manufacturing, retail, and construction (Kahn, et al., 2019).

To add even more specificity to the economic harm predicted from anthropogenic cli mate change, economists have created a metric known as the Social Cost of Carbon which aims to provide “An estimate of the economic costs, or damages, of emitting one additional ton of carbon dioxide into the atmosphere, and thus the benefits of re ducing emissions” (Errickson, et al., 2021). The Social Cost of Carbon was most fa mously approximated during the Obama Administration in order to inform much of its energy policy and mitigation efforts; however, subsequent research by environmental

economists has suggested that these government projections drastically undercounted the extent of the harm. The prominently displayed number generated during the Obama administration was $21 per ton of carbon dioxide, but recent estimates have projected that if the United States continues on business-as-usual emissions approach the social cost of carbon could really be more like $900 per ton of carbon dioxide and rise to nearly $1500 per ton by the year 2050 (Ackerman & Stanton, 2012). This may seem like a gloomy analysis of damage to come, but the point of the social cost of carbon is to provide a figure for the economic damage caused by harmful emissions and be able to compare this against the costs of reduction to better inform policy, and on this front, the data appears to be trending in a positive direction with some estimates suggesting expenditures of between $150 and $500 per ton of carbon dioxide on technology to reduce emissions could achieve the goal of being zero net emissions by 2100 mean ing that the mitigation costs appear to be far less than the potential costs of letting the problem continue unabated (Ackerman & Stanton, 2012).

3 The U.S. Power Grid and National Efforts

Climate change is a global problem with externalities from one country’s pollutants negatively impacting all other countries in some way necessitating some amount of in ternational cooperation on emissions mitigation and to some extent, this has been the case. The first major international agreement to address human-driven climate change was the 1997 Kyoto Protocols which set some of the first international carbon emission reduction goals and outlined potential policy solutions including setting up clean air and carbon credit marketplaces; however, the United States became the largest indus trialized country to refuse ratification of the Protocols and spearheaded opposition to participating in the agreement (Center for Climate and Energy Solutions, 2020). The Kyoto Protocols went into effect in 2008 on the countries who did ultimately ratify the agreement; however, without the inclusion of some of the largest emitters like the U.S., climate scientists forecasted that the modest goals of the protocols probably would not have a significant effect on mitigating global warming necessitating a new, more en compassing agreement (Center for Climate and Energy Solutions, 2020). In 2015, 196 countries signed the Paris Climate Accords which set a goal of limiting global temper ature rises to between 1.5 and 2 degrees Celsius, and this time the United States was a participant; however, this would not remain the case with the issue become a highly polarizing political issue (United Nations Framework on Climate Change, 2021). Pres ident Trump signed a directive in his first year in office intending to remove the United States from the agreement, but before the multi-year withdrawal could fully go into ef fect, newly elected President Biden reversed the decision (United Nations Framework on Climate Change, 2021).

Global action on climate change, especially concerning the United States, is sparse and inconsistent forcing policy decisions to lower levels of government. Nationally, Congress has yet to pass legislation specifically to address climate change with the last

significant effort to pass legislation occurring with the American Clean Energy and Security Act of 2009 which ultimately failed in the Senate (Center for Climate and En ergy Solutions, 2020). Since 2009 multiple attempts at legislation have been made but not passed and Presidential executive orders have temporarily been instituted, reversed, and reinstituted leaving the United States without a continuous national carbon emis sions reduction plan. The failure for action at the national and international level has opened an avenue for some states to begin addressing the problem piecemeal across the country creating a patchwork of different policies and shifting the debate on policy implementation to yet another more local level.

4 States in Action

Over the past decade, post-industrial states, in particular, have seen a substantial push for renewable energy policy with some states taking ambitious directives to achieve the emissions reductions the environmental Kuznets curve predicts is desirable for in dustrialized societies. However, every attempt at climate change legislation brings out many of the same concerns and counterarguments. Fears of the impacts renewable en ergy policies may have on employment, especially in areas reliant on the fossil fuel industry, are leveled along with a persistent concern among lobbyists and some legis lators that the increased costs of building out renewable energy infrastructure will be passed along to consumers as electric utilities raise the price of electricity. Despite these fears, many states have implemented renewable portfolio standards (RPS), which are designed with the intention of increasing the portion of electricity generated by re newable sources. Many of these policies have built-in funding and incentive programs to subsidize or increase investments in renewable energy sources. While there have been proposals for a nationwide RPS, there is no federal RPS currently in place. In stead, states have adopted their own programs. As of September 2020, 38 states and the District of Columbia had some form of an RPS in place. Of those 38 states, 12 have a requirement of 100% clean energy by 2050 (EIA, 2021). The main goal of these programs is to increase renewable energy production while maintaining low costs to consumers. The policies appear to be effective at increasing renewable energy produc tion, with the vast majority of states hitting their targets. It is estimated that nearly half of all growth in U.S. electricity generation is due to the implementation of an RPS (EIA, 2021). RPS programs come in a variety of forms, and so far it has been up to each state to set its own goals. Understandably, there is variation between different states' policies.

In 2004, Pennsylvania implemented an Alternative Energy Portfolio Standard (AEPS), requiring that 18% of the state's electricity retail sales come from sources other than petroleum, natural gas, and coal (EIA, 2021). The Pennsylvania state government pro vided loan and grant programs to individuals and businesses, lowering installation and interest payments on renewable energy projects (Ballotopedia.org). Since 2003 the price of electricity in Pennsylvania has increased by approximately 34% while the

F	7.1566
p-value	0.001048

Table 1: WV Chow Test

national average price of electricity has risen by 39% (EIA, 2021). IN 2007, North Carolina established a Renewable Energy and Energy Efficiency Portfolio Standard (REPS), which required that 12.5% of retail electricity sales come from renewable sources, and aims to cut carbon emissions by 70% from 2005 levels (North Carolina Department of Environmental Quality, 2020). In an attempt to lower the retail electric ity prices to consumers, the North Carolina state government put a cap on electricity prices (Wang, 2018).

However, since 2006 the average price of electricity per kilowatt hour in North Carolina has increased by 25%, while the national average has increased by only 19% (Statista, 2021). The North Carolina policy is currently under revision and it is worth noting that the changes in the price of electricity for both North Carolina and Pennsylvania may be due to factors other than the implementation of renewable energy policies and mandates. Despite the structure of the American Electric Grid having strict price controls on heavily regulated natural monopolies, electricity prices across the country have been continuously on the rise year after year, but whether this rise in price can be attributable to the implementation of renewable energy is a matter of debate without a consistently agreed-upon answer.

5 Environmental Policy and Electricity Pricing

To begin analyzing whether states implementing carbon mitigation policy had an effect on the price of electricity we began by looking for significant breaks in the pattern of pricing within states. West Virginia in particular stood apart as the only state that passed a law then explicitly removed the law within a couple of years. In the graph of electric ity prices for West Virginia seen in Figure 1, there appear to be breaks in the price of electricity in the year following both the implementation and repeal of the policy, and when we applied a Chow test to determine whether these breaks were significant, we saw that the break following the implementation of the policy resulted in significant changes in the price of electricity, but there was no significant break after the removal of the policy as can be seen in Tables 1 and 2 respectively. Furthermore, when we took a state with very similar characteristics to West Virginia, Ohio, and applied the same break test, we also saw a significant break in prices following their implementation of an emissions regulation policy as seen in Figure 2 and Table 3.

Once we saw these preliminary results suggesting policy may influence pricing we developed our model to look at the average electric prices to the ultimate consumer across all 50 states since the year 2001. We aimed to investigate whether the patchwork of renewable energy and carbon regulating policies were a primary driver of rising elec

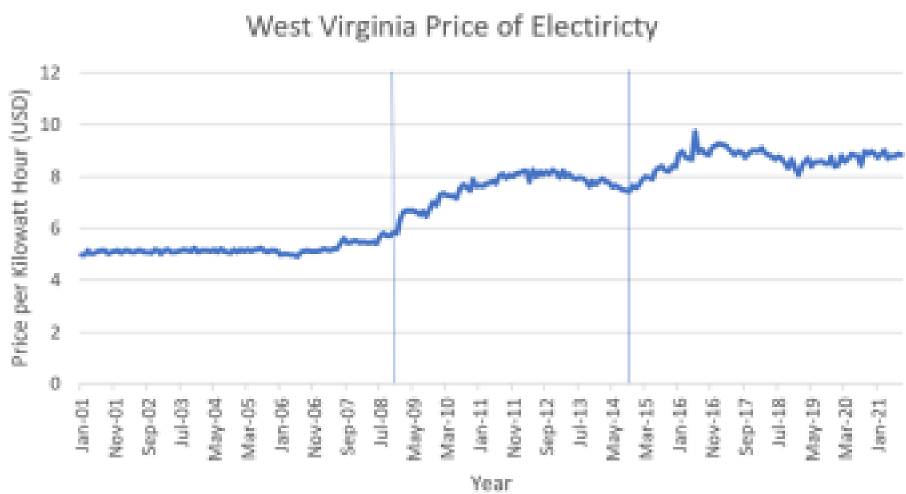

Figure 1: Graph of West Virginia Electricity Prices

	Policy Removal
F	-2.3181e-13
p-value	1

Table 2: WV Chow Test

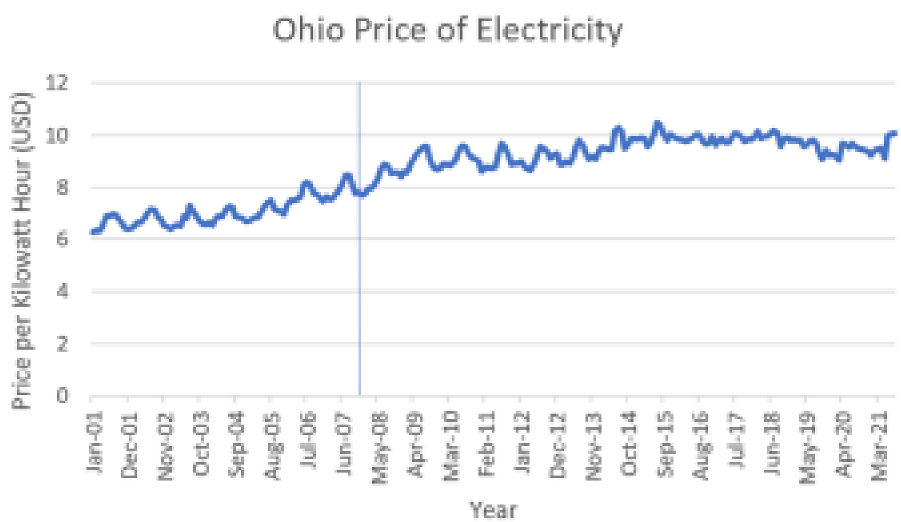

Figure 2: Graph of Ohio Electricity Prices

OH Chow Test

F 4.9871

p-value	0.007538

Table 3: OH Chow Test

Sample Statistics

Statistic	Mean	Standard Deviation
Retail Price	9.759	3.803
Policy	0.571	0.495
Natural Gas Price	4.427	2.190
Coal Price	77.227	33.335
Retail Price (ln)	2.218	0.333

Table 4: Sample Statistics

tricity prices to better inform policy debates. First we ran sample statistics on all our available data which can be seen in Table 4. In our model, we created a dummy vari able representing whether or not a renewable energy policy was present in a state and when the policy went into effect along with some other potential explanatory factors driving the price of electricity like coal and natural gas prices while taking into ac count the effect inflation has on the continuing increase in prices. To account for some potential outliers that could skew the data, especially geographically distinct entities like Alaska, Hawaii, and the District of Columbia which all have extraordinary power generating circumstances, and other unusual effects within states that may not have been accounted for in the model, we applied fixed effects on states to account for these variations and the results were shown in Table 5. While the results showed very sig nificant increases in electricity prices of nearly 16.3%, we wanted to account for other potential variations that occurred through changes in time that were not in the model, so we ran the model again this time only holding fixed effects for time and the results

	Model with State Fixed Effects
Intercept	2.028***
	0.009
Policy	0.163***
	0.004
Natural Gas Price	-0.027***
	0.001
Coal Price	0.002***
	0.000

Table 5: Model 1

	Model with State Fixed Effects
Intercept	1.931***
	0.321
Policy	0.233***
	0.005
Natural Gas Price	-0.036
	0.048
Coal Price	0.004+
	0.002

Table 6: Model 2

	Model with State Fixed Effects
Intercept	1.812***
	0.107
Policy	0.022***
	0.003
Natural Gas Price	-0.042**
	0.016
Coal Price	0.007***
	0.001

Table 7: Model 3

were shown in Table 6. Having fixed effects on time increased the effect of policy on prices to 23.3%. Finally, we accounted for both the variation in state and time and the resulting model summary is shown in Table 7. Once we accounted for both time and state, the effect of policy on price dropped off significantly to only 2.2% implying that most of the increases in prices seen are explained by some other individualized effects going on in certain states and is not mainly reliant on implementation of carbon miti gation policies.

Our ultimate model with state and date fixed effects included suggests when a state passes a renewable energy policy it is predicted to increase the price per kilowatt-hour of electricity by 2.2% holding the price of natural gas and coal constant. Addition ally, the model predicts that every increase in the price of natural gas by one dollar per thousand BTU will decrease the average price per kilowatt-hour of electricity by 4.2% ceteris paribus. The model also suggests that every increase in the price of coal by one dollar per metric ton increases the price per kilowatt-hour of electricity by 0.6%, ceteris paribus. We chose to include both natural gas and coal as other potentially explana tory variables because they represent the majority of fuel currently used to produce electricity in the United States and the results reflect this. The increase in the price of coal, which includes mining and transportation costs, appears to directly correlate with the price of electricity because this increase would be passed on to consumers; however, the increase in the price of natural gas appears to have an inverse effect on the price of electricity. This could probably be because natural gas is primarily used as a cheaper alternative to fossil fuels like natural gas so an increase in price might be reflective of increased demand and while natural gas may have an increasing price, it would still be relatively cheaper than coal meaning the price increase could just be a proxy for greater adoption of a cheaper method of electricity generation, but further research could potentially help isolate this effect.

6 Recommendations

States across the country have begun considering and adopting many different varia tions of climate change mitigation policy to fill the policy void provided by federal and international inaction, but these policy debates are nearly always framed as potentially having a negative impact on consumers as some suggest the increased cost of adapt ing to these policies will be passed on to consumers in the former of higher electricity prices.

- Based on our research and analysis we cannot rule out that implementation of these policies may, at least in the short run, result in higher average electricity prices; however, there are other costs to consider, such as the social cost of carbon when debating whether to implement some of these policies.
  - Additionally, the increase in electricity costs is primarily attributed to other factors besides policy with the effect of policy implementation being a one time, somewhat negligible, increase.
  - Given the significant negative effects climate change is predicted to have on major sectors of each state's economy reducing their GSP, this initial cost of renewable conversion pales in comparison to the high social costs of carbon without these mitigating policies.
  - Advocating for the implementation of a renewable energy mandate would help to substantially mitigate the long-term economic damages that climate change threatens to impose and while initially, these policies may result in higher electricity costs, it appears that consumers and utilities can ulti mately adapt to this new regulatory landscape.
  - Given this, it would be prudent for state legislators, who play a paramount role in addressing climate change, to pass carbon mitigation policies to pro tect long-term economic interests but legislators should consider including some mechanisms to soften the initial financial impact of these policies on consumers through

price controls or tax incentives.

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