Assessing the Inflation Reduction Act's Impact on Renewable Energy Adoption and Industry in the United States

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ABSTRACT

Changing weather and temperature patterns occur on a global scale and threaten the stability of our natural environment as a result of greenhouse gas emissions and the historic dominance of fossil fuels. Federal renewable energy policies are employed as a tool to limit national greenhouse gas emissions by encouraging a transition to renewable energy sources including solar and wind. The latest federal renewable energy initiative created in 2022 was the Inflation Reduction Act (IRA). While the IRA is widely regarded as the most ambitious federal renewable energy policy in history, it is currently unknown how the provisions of the IRA will actually impact renewable energy adoption. In order to determine the IRA's capacity to stimulate renewable energy adoption, I conducted a policy assessment that included regression analysis to predict how the IRA will financially support domestic renewable energy generation projects, tax model simulations to stimulate the profit capability of the IRA, and a survey of the popular opinion of solar energy companies in the United States regarding their view of the IRA. Through these methods, I found that the IRA's larger budget successfully promotes renewable energy generation and generates profits at an unprecedented level compared to past federal policies. In addition, the overwhelming majority of solar energy companies view the IRA's initiatives and economic strategies positively. These findings support the development of additional federal policies that can use similar economic strategies to further invest in renewable energy technology and phase out fossil fuels.

KEYWORDS

policy assessment, solar energy, profit margins, business survey, domestic energy manufacturing

INTRODUCTION

Though the disruptive environmental and health impacts associated with climate change have been established for decades, the United States continues to rely on fossil fuels for the majority of its energy usage. Climate change is driven by the emission of greenhouse gasses (GHG) via the burning of fossil fuels to provide energy. The emission of GHG into the atmosphere disrupts typical weather patterns and natural processes because GHG has the ability to trap heat or solar radiation in the atmosphere (Panwar et al. 2011). Climate change is a continuously growing problem that needs to be addressed by policy makers because shifting weather patterns negatively impact ecosystem and human health via respiratory diseases, access to food and water, and danger from natural disasters (Glicksman 2023). Because of its scale, climate change is considered a global issue which impacts everyone but the contribution to the global phenomenon is unequally distributed across different countries. The United States is responsible for the greatest cumulative GHG emissions and is thus the greatest global contributor to global temperature change at 15.1% (Matthews et al. 2014). In order to change the position of the U.S. as the most prominent GHG emitter, changes in our usage of fossil fuels and nonrenewable energy are necessitated.

The use of energy technology and the burning of fossil fuels by both producers and consumers can be influenced by national policies that incentivize a transition to renewable energy while discouraging the emission of greenhouse gasses. Policy provisions directed at producers to reduce GHG emissions and encourage renewable energy adoption include carbon taxes, subsidizing renewable energy technologies, cap and trade programs, and clean energy standards (Fischer and Newell 2008). In addition, strategies used to change consumer behavior include credits and net metering, subsidies, carbon offsets, rebates on electric vehicles, and investment to provide affordable renewable energy technology (Dubois et al. 2019). These methods have been used by the United States on both federal and state levels to primarily expand energy conservation and efficiency (Dixon et al. 2010). Major environmental economic policies in the U.S. that attempted to reduce emissions include the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and the Emergency Economic Stabilization Act of 2008. However, despite the importance of policies as a key tool to fight climate change and the aforementioned policy attempts to make significant changes in increasing the United States' clean energy usage, a national transition towards renewable energy and away from fossil fuels has not yet occurred.

The newest federal policy in the United States intended to encourage the usage of renewable energy technology is the Inflation Reduction Act. The goal of the Inflation Reduction Act (IRA) is to promote a national transition to clean renewable energy to mitigate climate change and the health impacts associated with it (Glicksman 2023). To achieve this goal, IRA legislature provides funding for the accelerated growth and development of clean energy, consumer rebates for home electrification, and resources to support domestic manufacturing (Barbanell 2022). The IRA is different from past initiatives because it wields the influence of being a federal law as well as provisions focused not only on manufacturer's energy consumption but how consumers can contribute to its mitigation via credits and incentives (Rudolph et al. 2022). Although it is well established that the IRA was designed to be distinct from past federal policies that targeted renewable energy in regards to the budget and incentives provided, the actual effectiveness and improvement of the IRA compared to past policies has not been measured.

In this study, I explore how the future effectiveness of the Inflation Reduction Act's initiatives can be evaluated in comparison with other environmental economic policies. Broadly, I am interested in how companies and industries in the United States responded and benefitted from the establishment of the Inflation Reduction Act. By assessing the IRA's profit capabilities, support for renewable energy generation, and public opinion, I expect to find that the IRA is an unprecedentedly successful federal renewable energy policy. Specifically, I ask [SQ1] "What is the relationship between the scale of corporate tax credits offered and industry energy production and investment", [SQ2] "How will companies be affected by claiming tax credits for solar energy investment versus production", and [SQ3] "How have businesses and industries responded to the proposed incentives by the IRA?" My hypothesis for my first question is that depending on the formula created for different businesses, either investment or production will create a bigger profit resulting in no overall winner. To test this hypothesis I will use ITC and PTC values available from the Federal Office of Energy Efficiency and Renewable Energy. My hypothesis for my second subquestion is that the variable of tax credits will have a statistically significant impact on solar energy investment. The data I need to test this hypothesis includes federal investment data about the American Recovery and Reinvestment Act, tax credit values, and national renewable energy production data. Finally, my hypothesis for my third subquestion is that the majority of renewable energy businesses hold a positive opinion of the IRA. I will address this hypothesis using data from news articles, social media posts, company websites, and opinion pieces.

BACKGROUND

Greenhouse gas emission timeline

Fossil fuels have been established as the primary global energy source for decades, but they haven't always been so. The Industrial Revolution from its start in the late 1700s represents a fundamental shift in energy usage in human history that transitioned a dependency on human and animal power to fossil fuel powered machines (Huber 2009). Fossil fuels refer to solar-based biological life formed under the Earth's crust such as coal, oil, and natural gas (Huber 2009). After the Agricultural Revolution spurred population growth amid the colonial growth of the British Empire, a more powerful energy source was needed by both industry and domestic sectors to maintain economic and social growth. Fossil fuels were well suited to become the dominant source of energy in Britain due its status as a geographically mobile and highly concentrated source of energy that does require land-use, unlike timber (Huber 2009). The introduction of new technology such as the steam engine by James Watt relied on coal to meet these increased energy demands (Malm 2016). The superior energy concentration of fossil fuel-based machines can be demonstrated by Watt's steam engine, which by initially producing an average of 20 kW was already five times more powerful than contemporary watermills, three times that of windmills, and 25 times the performance of a horse (Smil 2017). By 1850, Britain had established a fossil fuel economy powered by a coal industry that was responding to a nationwide increase in demand for fuel for both domestic and industrial purposes (Malm 2016). While coal was the beginning of global fossil fuel usage, it would not be the only fossil fuel used to drive economies forward.

Though they were adopted on an industrial scale later than coal, oil and natural gas would join coal to establish fossil fuels as the globally dominant energy source. After the mid nineteenth century, a wave of new innovations popularized fossil-fuel based technological systems. Following the development of the steam engine which gave way to the large-scale production of coal, the creation of the steam turbine used for electricity generation popularized other fossil fuels (Jones and Mayfield 2016). The development of electricity networks and the internal combustion engine used to power transportation systems created an unprecedented demand for oil which, today, still accounts for more than half of global fossil fuel use (Pirani 2018). In addition, natural gas joined coal combustion as the two most common methods used to produce power and electricity (Jones and Mayfield 2016). By 1900, fossil fuel consumption and production was present on all continents, with a majority based in the United States, Britain, Germany, and France (Pirani 2018). Altogether, coal, oil, and natural gas came together to create a fossil-fueled civilization that relied on these energy sources to power transportation, war, industry, and domestic living (Koppelaar and Middelkoop 2017). However, the societal transformations and economic booms that relied on fossil fuels came at a detrimental cost; the health of the environment.

In addition to providing reliable and powerful energy, fossil fuels are a major global contributor to greenhouse gas emissions. Greenhouse gasses include atmospheric gasses such as carbon dioxide that block long-wave solar radiation from leaving the Earth's atmosphere. This process creates a balance between the incoming and outcoming solar radiation on Earth that has maintained habitable temperatures and is vital for plant growth (Armstrong et al. 2018). However, rising levels of greenhouse gas emissions distorts this balance and the resulting increased trapped radiation in the atmosphere creates a rise in global temperatures (Armstrong et al. 2018). The result of changing temperatures and weather patterns are often severe weather events that threaten the environment and human health via air pollution, heat stress, food insecurity, natural disasters, and more (Macpherson 2014). Even though anthropogenic emissions of greenhouse gasses have negative health and environmental impacts, emissions have become unavoidable because they are largely caused by the use of fossil fuels. The combustion of fossil fuels and subsequent emission of carbon dioxide gas has contributed to about 70% of total global greenhouse gas emissions (Johnsson et al. 2018). However, while fossil fuels are used worldwide, the scale of consumption and subsequent greenhouse gas emissions are not distributed evenly across countries.

After centuries of fossil fuel consumption, the United States has solidified its leading position as the biggest historical greenhouse gas emitter. In the late 1800s, the United States made the decision to transition from traditional energy sources to a newer path forged by nonrenewable energy. This decision created a long-term national dependency on fossil fuels to meet rising energy needs, as shown by how coal, oil, and natural gas accounted for nearly 90% of the nation's energy budget within decades (Johnson 2014). Continuing on, the twentieth century would see the United States develop a high-energy economy through investments in electrification projects, a federal infrastructure of highways, private energy markets, and lifestyle improvements ranging from automobiles to electric washers and dryers (Johnson 2014). Overall, the United States was established early in history as a major producer and consumer of energy as it industrialized as seen in how U.S. gross energy production increased by more than 200 times between 1850 and 1960 (Melosi 1987). The development of American society and economy inevitably emits greenhouse gasses at every stage; producing exports and imports, heating homes, fueling vehicles, and many more (Erickson and Lazarus 2013). Basic resources including food, transportation, and housing are all critically dependent on fossil fuels (Jones and Mayfield 2016). As a result of how ingrained into society fossil fuels have become, the United States has been established as the biggest historical contributor to greenhouse gas emissions (Parker and Blodgett 2008). All the technological innovations used by the United States to grow its economy have created a society where living a low carbon footprint lifestyle is unaffordable and often unavoidable due to the convenience and prevalence of fossil fuels in the U.S. (Parker and Blodgett 2008). Though the United States is aware of its historic contribution to greenhouse gasses and the resulting environmental damage this has caused, this trend is likely to continue in the future.

The future of greenhouse gas emissions and policy

In the midst of growing global populations and economic growth, future energy demands will continue to rise. The late twentieth century saw a shift in the source of global energy demand from developed to developing countries and regions. The Organization for Economic Cooperation and Development (OECD) is an international forum of 38 members that represent the world's largest economies, including the United States, Germany, Canada, France, Norway, Australia, and more (OECD 2021). OECD countries, commonly grouped as developed countries, are historically responsible for the largest share of energy consumption. However, development in non-OECD countries in Asia, Africa, and the Middle East has shrunk the aggregate share of energy consumption of OECD countries from 60% to 41% between 1970 and 2010 (Gordon 2015). As non-OECD countries reach higher stages of development through greater modernization and mobility, greenhouse gas emissions will continue to grow because this development is reliant on fossil fuels (Gordon 2015). Pollution, including greenhouse gasses such as carbon dioxide, tends to increase alongside income until a threshold level is reached and a demand for environmental quality can be afforded, leading to a decrease in emissions (Roach 2013). So, until threshold development is achieved in all countries, rising income accompanied with continued growth in our global population will result in a significant increase in energy consumption (Roach 2013). Current research on future energy demand has modeled and predicted that increasing population and income resulting in growth in residential and industrial sectors and increased demand for transportation will increase global primary energy usage between 16% and 57% by 2050 as compared to 2022 (EIA). Because growing energy demands are inevitable, the development of renewable energy technology to mitigate greenhouse gas emissions is vital.

Renewable energy was the primary energy source for much of human history and it has the potential to meet our future energy demands. Before fossil fuels began playing a significant role in the economy, human history relied on energy sources that were considered renewable. Renewable energy refers to energy sources that are naturally replenished by Earth at a higher rate than they are consumed and have low greenhouse gas emissions (Blakers et al. 2017). Prior to the establishment of fossil fuel societies, the dominant sources of energy worldwide were human and animal power, biofuels, water wheels, and windmills (Huber 2009). Biofuels refer to fuel sourced from living matter and commonly includes wood that was used globally to generate heat and steam (Huber 2009). Water, or hydropower, was also being used by societies for centuries to generate energy via water-wheels that powered machines such as grain and lumber mills (Huber 2009). In addition, global empires have harnessed wind power going back 2000 years via windmills and structures that pumped water for irrigation, transported goods, and milled grain before eventually evolving into modern wind turbines (Usher 2022). These traditional sources of energy were replaced by fossil fuels over time because of their limitations regarding geography and energy concentration, but they have been recently revitalized by modern innovations focused on improving their efficiency.

As a result of investments in renewable energy technology on a global scale, the current state of renewable energy usage in the United States is on an upward trend. Modern renewable energy resources refer to solar energy, bioenergy, hydroelectricity, and wind energy that are used in electricity generation, heating and cooling, and bio-products (Aslani and Wong 2014). Solar power is one of the fastest-growing renewable energy markets due to its ability to generate and store electricity generated and captured by photovoltaic cells that harvest solar energy without greenhouse gas emissions (Echeverría et al. 2020). Next, bioenergy refers to biomass such as wood or agricultural crops that are converted into energy including heat, liquid fuels, and electricity (Herzog et al. 2010). Biomass' main benefits for the environment besides a reduction in greenhouse gas emissions are that it provides energy in rural areas with less development, has a high potential for job creation, and reduces the amount of biomass accumulating in landfills (Echeverría et al. 2020). Finally, grid-connected wind power is sourced from wind turbines that function from the propelling of blades attached to a rotor that spins a generator to generate electricity without greenhouse gas emissions (Herzog et al. 2010). Due to investments in renewable energy technology that have improved energy efficiency, the technical combined potential of the major renewable energy technologies are capable of providing more than five times the amount of electricity needed by the United States (Deyette et al. 2003). In regards to the current state of renewable energy in the United States, renewable energy sources are responsible for about 20% of electricity generation (EIA). The energy potential of renewables were considered promising in the early 2000s, and by 2023 the EIA has confirmed that they expect zero-carbon technology to meet the most of new energy demand through 2050 (EIA). Renewable energy sources have the capacity to power the future, but strong climate policy will be necessary to regulate and fund this transition.

The first renewable energy policies established by the U.S. originated in the late 1900s in response to the stagnant growth of renewable energy. Prior to the early 21st century, renewable energy in the United States was an available but often not chosen alternative to fossil fuels only mandated by the Public Utilities and Regulatory Policy Act (PURPA) of 1978 that required utilities to purchase power at the utility's 'avoided cost' which ultimately led to the construction of 12,000 MW of renewable power being constructed during the 1980s (Martinot et al. 2005). Growth for renewable energy during this time period was regarded to be stagnant because at the time, renewables were facing competition from drastically lower natural gas prices, electric power sector restructuring, and the repeal of federal and state incentives (Martinot et al. 2005). Progress for renewable energy sources was renewed with the development of state energy policies including renewable portfolio standards (RPS), net metering policies, and other financial incentives that subsidized purchasing renewable energy systems (Martinot et al 2005). RPS are considered to be the most influential state policy in regards to encouraging renewable energy usage since they established a requirement for energy producers and users to "derive a certain percentage of their electricity from renewable sources" (Fischer 2010). Another major renewable energy policy were mandatory green power options (MGPO) which encouraged the development of renewables by mandating electric utilities to source or sell specified percentages of renewable energy (Delmas and Montes-Sanchos 2011). Overall, these state initiatives were integral to the growth of renewable energy given roughly half of renewable energy generation in the United States since the early 2000s can be attributed to state renewable energy requirements (NCSL 2021). As renewable energy continued to grow at local and state levels, federal policies brought additional progress with the establishment of production tax credits (PTC) for renewable energy resources to financially incentivize companies to produce electricity from renewables (Martinot et al. 2005). The use of PTC to reduce renewable energy costs would be an effective financial policy tool adopted in succeeding federal energy initiatives including the Inflation Reduction Act.

The Inflation Reduction Act of 2022 represents the United States' most recent and ambitious federal renewable energy initiative. The Inflation Reduction Act (IRA) was ratified in the midst of growing concerns of the climate crisis posed by climate change and greenhouse gas emissions. Part of the IRA's motivation includes greenhouse gas emission reduction goals set by the Paris Agreement, an international treaty of climate from the UN Climate Change Conference in 2015, to hold global temperature changes below 2°C (Bistline et al. 2023). The Paris Agreement aimed to limit global warming by creating a long-term goal for head-of-governments to make cuts in global emissions (Schleussner et al. 2016). Additionally, the Paris Agreement established nationally determined contribution (NDC) standards which set a self-defined country emission reduction target along with requiring the country to outline their finance and adaptation plans to create these emissions reductions; the latest target for the U.S. has been set at 50–52% (State Department 2021). To help the U.S. achieve this target, the IRA allocates federal funding to accelerate the growth of renewable energy and domestic manufacturing by expanding production and investment tax credits, incentivizing homes to transition to rooftop solar and energy-efficient retrofits, and expanding the finance authority of the Department of Energy's Loan Programs Office (Barbanell 2022). As a result of these financial incentives, preliminary modeling expects the IRA to reduce greenhouse gas emissions by up to an additional 11% by 2030 compared to 2005 emission levels (Barbanell 2022). All assessments of the IRA's capabilities and impact on greenhouse gas emissions are based on preliminary data because not enough time has passed since the policy was established to measure its effects; this leaves a current gap in knowledge regarding the actual impact that the IRA will have on the current state of renewable energy.

Research framework

Methodology

To answer the question of how effective the IRA is at promoting renewable energy while considering its relationship with businesses, I considered past policy assessments. My method to answer my first subquestion, "What is the relationship between the scale of corporate tax credits offered and industry energy production and investment?", was a regression analysis based on a past federal economic policy, the ARRA. To study a similar issue, one study titled "Effectiveness of renewable energy incentives on sustainability" on the relationship between policies and energy established a framework where they found that grants, taxes, certifications, and policy support all have positive and statistically significant impacts on renewable energy deployment (Kaplan and Boluk 2021). This framework used correlation to test the relationship between type of policy incentive and renewable energy adoption, which is a method similar to my own except that I am measuring renewable energy adoption through the construction of renewable energy manufacturing facilities. The methods of regression addresses the subquestion because determining correlation between the amount of tax credits offered and industry behavior suggests that their relationship is statistically significant and can be used to predict the IRA's impact. The strength of correlation as opposed to an alternative approach of assessing policy via predictive energy models is that it relies on real data from the same country and type of policy instead of generating data which creates a lower margin of error.

My second method involving tax credit profit simulations draws from a similar framework established by previous programming studies. To address my second subquestion, "How will companies be affected by claiming tax credits for solar energy investment versus production?", I modeled profit simulations for different hypothetical renewable energy companies. A previous study approached a similar issue of guiding policy makers to the best production tax credit scenario by programming model scenarios of the biofuel industry where different variables including land size and mix of crops were compared against each other to attain the best selection of tax credit variables (Bard et al. 2000). This establishes a framework for profit assessment where model simulations can be used to calculate and compare the profits of a company with different variables, including solar availability and land availability in my case. This method effectively addresses my research question because after comparing the profit margins of each model I determined if ITC or PTC are more profitable for renewable energy companies. However, one weakness of this method also acknowledged by Bard et al. includes the exclusion of additional real-world variables such as political instability by taking an "engineering approach" (Bard et al. 2000).

To address my third subquestion, "How have businesses and industries responded to the proposed incentives by the IRA?" I conducted a survey on the opinions of solar energy companies of the IRA. I chose to include the metric of popular opinion on my study's overall assessment of the success of the IRA because of concepts established by previous studies on how public opinion shapes policy. One article titled "The Impact of Public Opinion on Public Policy: A Review and an Agenda" studied the impact of public opinion on public policy and found that even when taking political parties and interest organizations into account, public opinion substantially impacts policy in a statistically significant way by influencing its development (Burstein 2003). When taking the importance of public opinion into account, it is important to assess how the companies most directly impacted by the IRA's establishment, renewable energy companies, consider the IRA to be beneficial. Therefore, this method helps address my research question because it will provide a more complete overview of the IRA's success beyond its ability to create profit or reduce greenhouse gas emissions. While conducting a survey of the largest solar energy companies will gauge the opinions of the most influential companies, this survey's weakness compared to an alternative method of including small companies is that the results will be less generalizable. The confluence of my regression, tax profit models, and business survey helps me address the current gap in knowledge regarding the future impact of the IRA by providing three metrics, renewable energy manufacturing, profit, and popularity, to measure its success.

METHODS

Data collection

To determine the relationship between the scale of corporate tax credits and energy production investment, I collected data from policy analysis conducted on the American Recovery and Reinvestment Act of 2009 (ARRA). The Inflation Reduction Act is still a new policy and data regarding the success and impact of the policy has not been generated yet. Until then, projections about the effectiveness of the IRA's provisions can be created by comparing it to the ARRA because both policies included the same type of renewable energy manufacturing tax credit under Section 48c. The main purpose of the ARRA was to stimulate the economy and generate spending by providing a variety of grants to states amidst the 2009 recession (Wyatt 2009). In order to achieve this goal, one provision of the ARRA under Section 48C established the "Advanced Manufacturing Tax Credit" which budgeted $2.3 billion towards providing a 30 percent investment tax credit to over 180 clean energy manufacturing facilities in the United States (White House 2010). The Inflation Reduction Act expanded upon this existing tax credit with a larger budget of $10 billion to achieve the same progress of clean energy job creation and greenhouse gas emission reductions but on a more impactful scale. Furthermore, I sourced specific information about the ARRA's budget, allocated credits, and actual impact from federal government reports and national archives.

To determine how companies will be affected differently by choosing to claim tax credits for energy investment or energy production, I used data on ITC and PTC values over time. The Federal Office of Energy Efficiency and Renewable Energy (EERE) provides a summary of investment tax credit and production tax credit values over time. The investment tax credit (ITC) is a tax credit that reduces the federal income tax liability for up to 30% of the cost of a solar project that is installed during the tax year (EPA 2023). On the contrary, the production tax credit (PTC) is a per kilowatt-hour (kWh) tax credit which can amount up to 2.75¢/kWh for electricity generated by solar technologies for the first 10 years of a system's operation (EPA 2023). The EERE also details bonus credits that are available to solar projects based on siting in energy communities, domestic content minimums, and qualified low income or economic benefit projects (Energy 2023). Additionally, in order to create tax credit simulations for solar energy companies, I sourced data about the average costs and solar energy production capacity of solar energy farms from the Solar Energy Industries Association's "Solar Market Insight Report 2023 Q3" which provides major trends of the U.S. solar industry (SEIA 2023).

In order to analyze how businesses and industries have responded to the IRA, I conducted a survey to compile opinions from solar energy companies about the IRA's design, impact, and success. The main information gathered by the survey cataloged the opinions of different companies and industries on how valuable they perceive the IRA to be based on the adjectives they used to describe the policy. For this survey, I sourced the chosen companies from Solar Power World's 2023 list of "Top Solar EPCs" which compiles a list of the top companies that perform solar engineering, procurement, and construction work ranked by the amount of kilowatts annually installed (Solar Power World 2023). I chose to survey the opinion of the biggest solar development and installation companies because they represent a majority of energy manufacturing in addition to holding influence over a larger market of customers and other companies. To determine the opinion of each company of the IRA, I used the Google search engine with the search terms of the company name accompanied with *Inflation Reduction Act.

Regression analysis

In order to analyze the relationship between the scale of corporate tax credits and energy production and investment, I used regression analysis. After collecting data from government reports and databases, I used the statistics software R, version 4.3, to conduct a regression analysis to predict how the independent variable of the amount of tax credit will affect the dependent variable of energy production and investment. Both the ARRA and IRA have known tax credit values of $2.3 billion and $10 billion respectively, but renewable energy production and investment for the IRA is unknown. Once a relationship between the two variables was established, I created a projection about how the IRA will impact renewable energy manufacturing in the future. The assumptions of regression analysis include a linear relationship between variables, independence, homoscedasticity, and normality (Hae-Young 2019). Homoscedasticity refers to the assumption of equal or similar variance between the groups being compared (Hae-Young 2019). Given these assumptions fit within the context of policy analysis because the data was collected at one time period and is normal without outliers, regression analysis was a good fit. Furthermore, I chose regression analysis because the relationship strength calculated between two variables can be used to model their future relationship and thus project the IRA's manufacturing impact.

Tax impact models

In order to analyze how companies will be affected differently by choosing to claim tax credits for energy investment or energy production, I created formulas to model different solar energy manufacturing company profits gained by decreases in their federal tax liability. The Federal Office of Energy Efficiency and Renewable Energy provides a summary of investment tax credit and production tax credit values over time. The investment tax credit (ITC) is a tax credit that reduces the federal income tax liability for up to 30% of the cost of a solar project that is installed during the tax year (EPA 2023). On the contrary, the production tax credit (PTC) is a per kilowatt-hour (kWh) tax credit which can amount up to 2.75¢/kWh for electricity generated by solar technologies for the first 10 years of a system's operation (EPA 2023). Given a company has to choose one type of tax credit, I created 5 scenarios in R and graphed the results in the spreadsheet software Microsoft Excel 2021 to test how choosing to claim either ITC or PTC credits created different profit margins. Each scenario represented a different solar energy company of unique production capacities, project costs, solar availability, and project lengths. Based on these different variables in addition to the formulas created with the ITC and PTC values, I ran each scenario and compared the sizes of tax credits to determine which type of tax credit would be more profitable. I chose to run simulated scenarios in Microsoft Excel and R because it allowed me to add and change the parameters of each solar project with ease to best account for different projects.

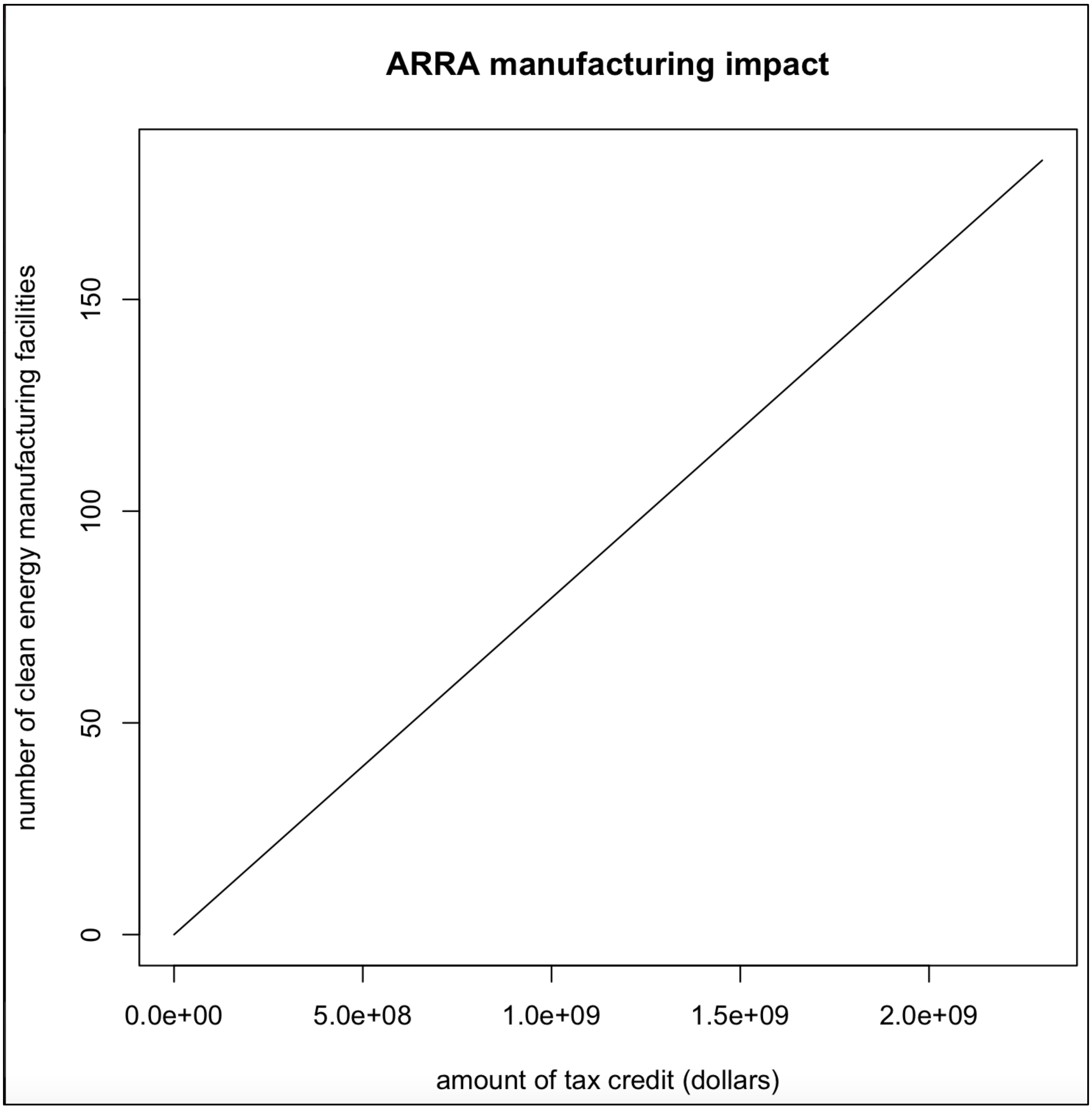
Business survey

In order to analyze how businesses and industries have responded to the IRA, I compared the compiled opinions and behavior changes from before and after the IRA was established. After reading each company statement, I assigned a company an overall opinion of either positive, negative, neutral, or no opinion based on the language and indicator words used. For example, a company that described the IRA as a “big win” and emphasizes the “benefits” that the bill brings would be categorized as positive. On the other hand, a statement that used language which stressed the policy’s shortcomings including its “room for improvement” or that the IRA does “not achieve enough” would be categorized as negative. A company was also categorized as having no opinion of the IRA if I could not find a company statement online under my search parameters. After conducting the survey and recording the results in Microsoft Excel, I formatted my data in a pie chart so they could be easily summarized. The main sources of company opinions searched on Google included official company statements from their websites, news articles, and social media posts predominantly from Linkedin. I chose to conduct a survey to gauge the IRA’s impact on companies as opposed to analyzing or projecting profits and energy data because it provides additional insight into the benefits and progress that the IRA can achieve.

RESULTS

Regression analysis

After performing regression analysis, I found that the independent variable of tax credits has a statistically significant impact on the dependent variable of energy production and investment. I used an alpha level of .05 for this statistical test. Based on the strong positive correlation between tax credits and energy production and investment, I calculated the IRA’s renewable energy manufacturing impact as measured through the construction of clean energy manufacturing facilities. As determined after the policy’s establishment, the ARRA’s tax credit budget of $2.3 billion directly resulted in the construction of 183 manufacturing clean energy facilities (Figure 1). Thus, I projected that the IRA’s budget of $10 billion for the same type of tax credit as the ARRA would be able to fund the construction of 795 clean energy manufacturing facilities (Figure 1). Given it was allotted a larger amount of tax credit dollars compared to the ARRA, the IRA is able to fund more than 4 times more clean energy manufacturing facilities (Figure 1).



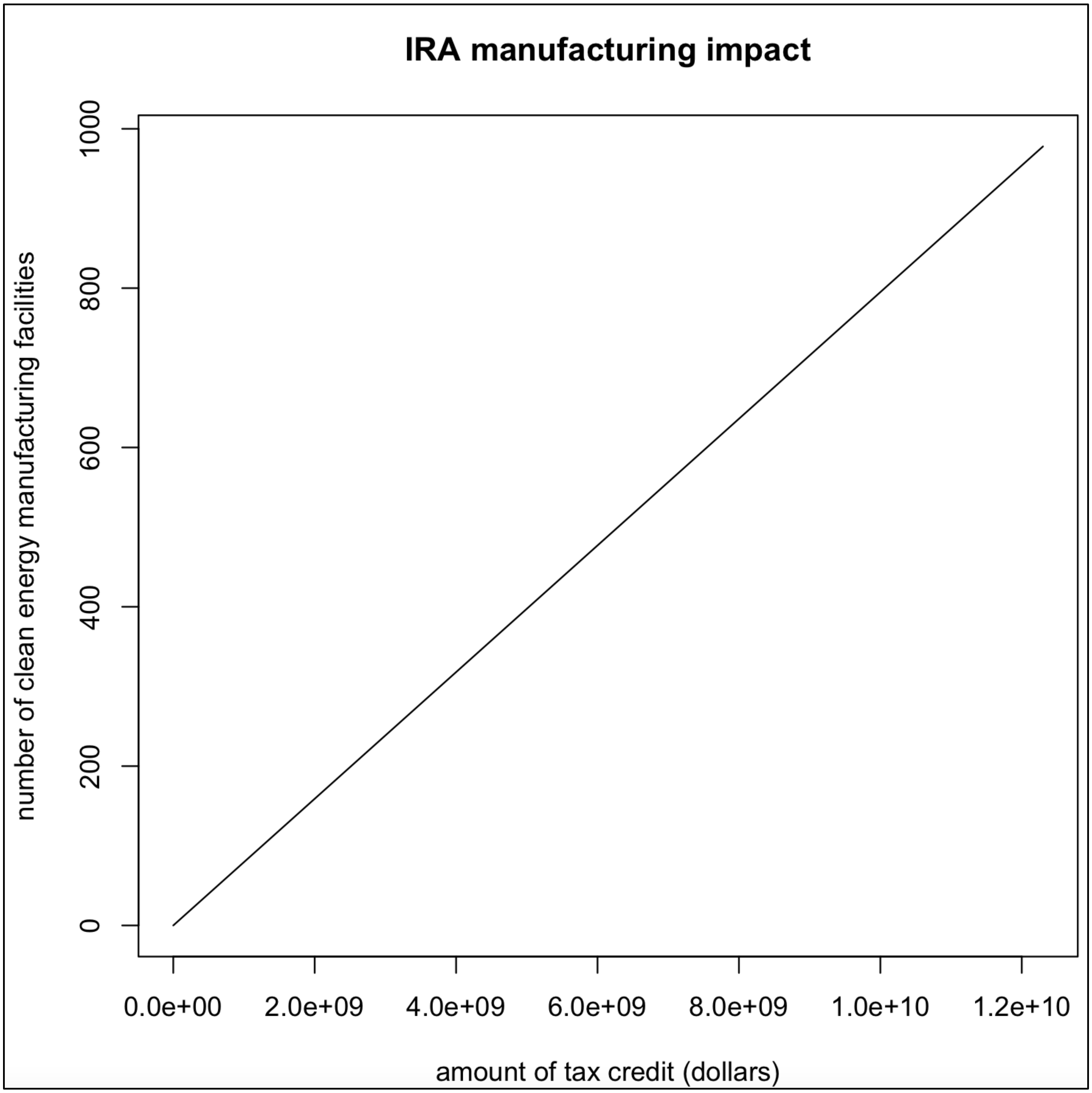


Figure 1. Contrasting manufacturing impacts of the IRA and ARRA measured through the construction of clean energy manufacturing facilities. Due to the IRA's larger budget of $10 billion, it has the capacity to support the construction of about 4 times more facilities than the ARRA's budget of $2.3 billion.

Tax impact models

In scenario 1, the solar company owns a 1 MW solar farm located in an environment with average sunlight availability. This 1 MW farm required an upfront cost of $800K to manufacture and install. Over 5 years of solar energy production, it would generate 7,500 MW of solar electricity. Given these variables, the solar company would receive a $240,000 decrease in their tax liability under ITC (Figure 2). On the other hand, if the solar company chooses to claim PTC it would receive $206,250 (Figure 2). For the example of scenario 1, ITC is the tax credit option that would provide greater financial benefit for the solar company.

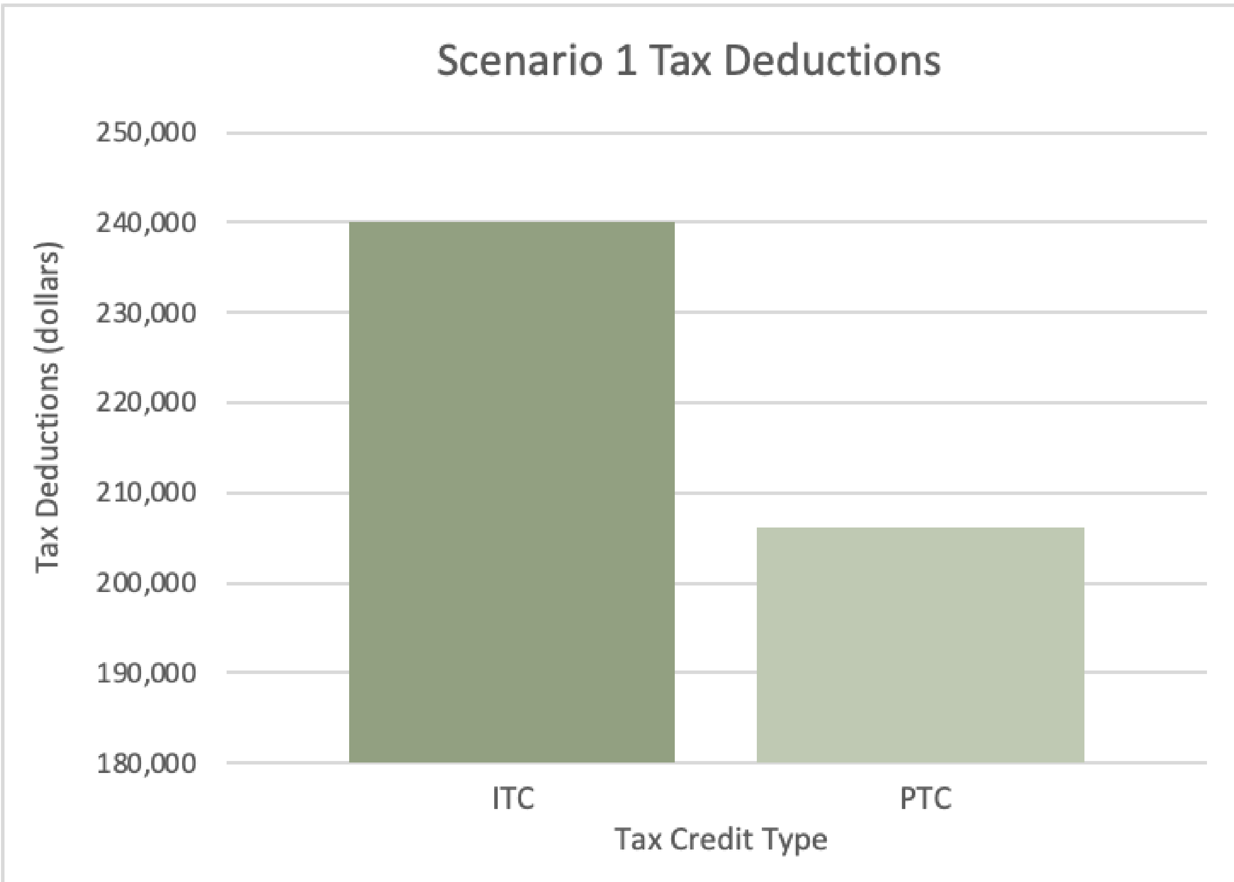


Figure 2. Tax deductions earned by the solar company from Scenario 1 for claiming either ITC or PTC values. The solar company would gain an additional $33K by claiming ITC tax credits, making ITC the more profitable credit option.

Scenario 2 is a 1 MW solar farm located in a similarly sunny environment which provides average sunlight availability for solar electricity generation. Scenario 2's 1 MW farm also requires an upfront cost of $800K to manufacture and install. Given the farm's plans to operate for 10 years, it would generate a total of 15,000 MW of solar electricity. Under these conditions, the solar company would receive a $240,000 decrease in their tax liability under ITC

(Figure 3). Conversely, if the solar company instead chooses to claim PTC, it would receive a $412,500 decrease in their tax liability (Figure 3). As a result, for Scenario 2, PTC is the tax credit option that would return the greater amount of tax credits for the solar company when compared to ITC.

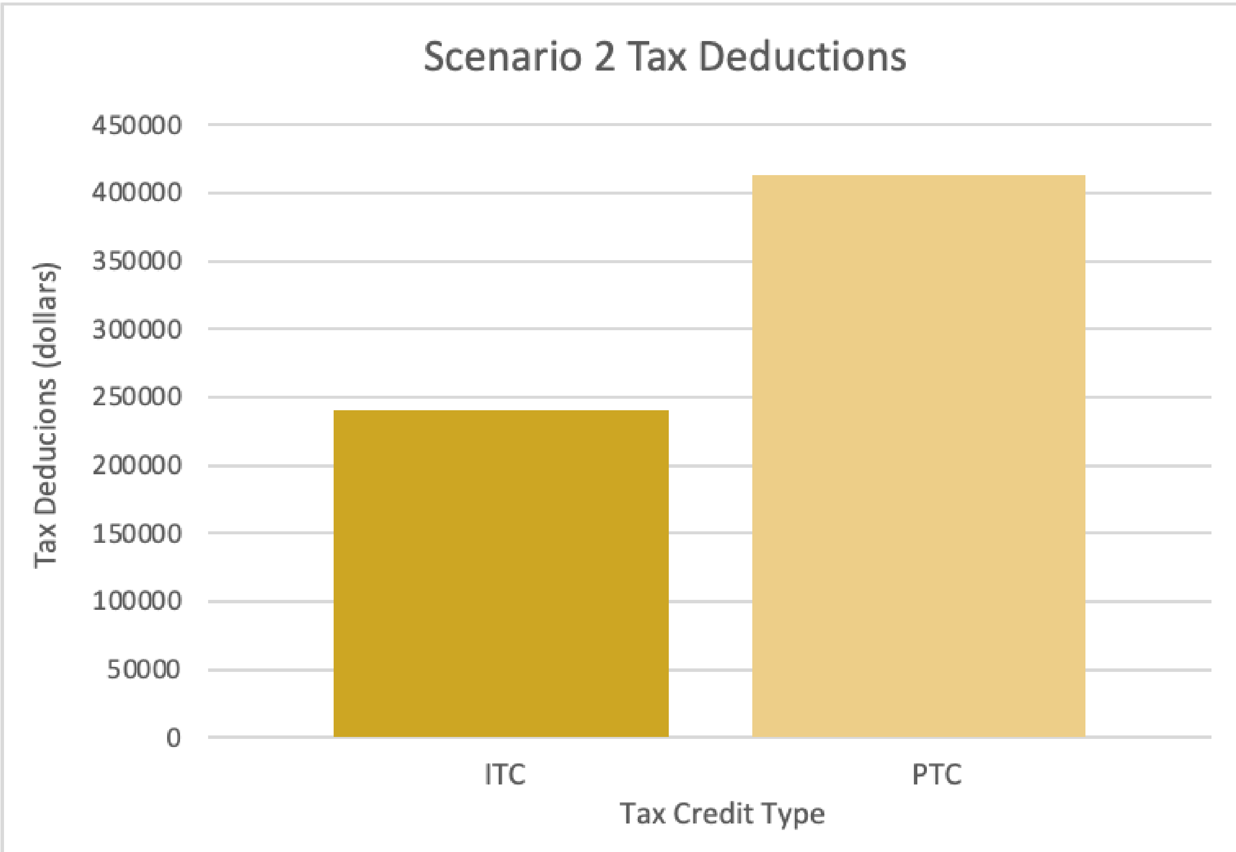


Figure 3. Tax deductions earned by the solar company from Scenario 2 for claiming either ITC or PTC values. The solar company would gain an additional $172K by claiming PTC tax credits, making PTC the more profitable credit option.

Scenario 3 involves a 1 MW solar farm that is located in an environment with less than average sunlight availability. As a result of the solar farm's location, their solar electricity generation capacity is reduced by 20% compared to average sunlight capacity and 10 years of electricity generation will yield 12,000 MW of solar electricity overall. Finally, Scenario 3's solar farm requires an upfront cost of $800K to manufacture and install. Considering these parameters, the solar company in Scenario 3 would receive a $240,000 decrease in their tax liability under ITC (Figure 4). Alternatively, if the solar company chooses to claim PTC it would receive $330,000 (Figure 4). As a result, PTC would return more money back to the solar energy company of Scenario 3.

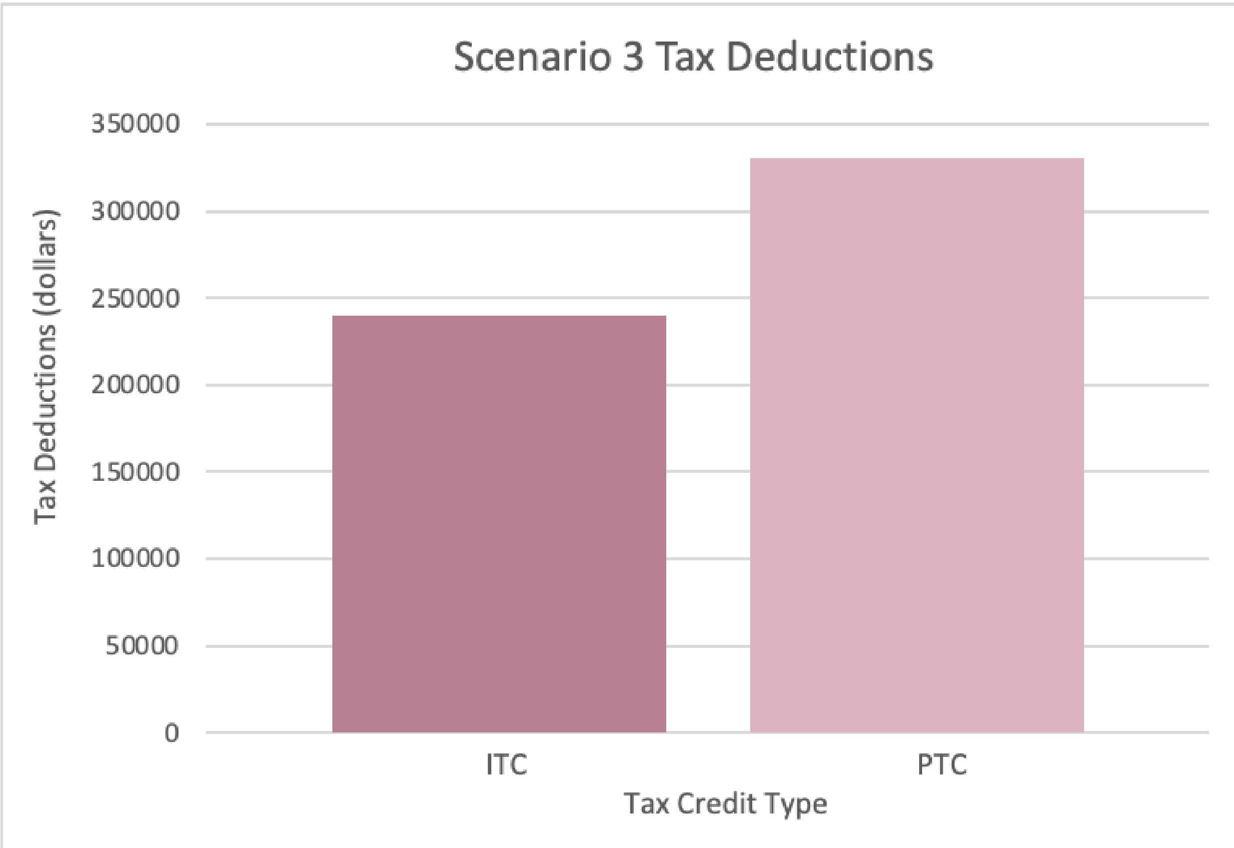


Figure 4. Tax deductions earned by the solar company from Scenario 3 for claiming either ITC or PTC values. The solar company would gain an additional $90K by claiming PTC tax credits, making PTC the more profitable credit option.

Scenario 4 simulated a ½ MW solar farm located in a sunny environment which provides average sunlight availability for solar energy conversion into electricity. Scenario 4's solar farm's smaller size resulted in a lower total construction and manufacturing cost of $400K. After operating for 10 years, the solar farm generated a total of 7,500 MW of solar electricity. Under these conditions, choosing to claim ITC would result in the solar company receiving a $120,000 decrease in their tax liability (Figure 5). On the other hand, if the solar company chooses to claim PTC instead, it would receive $206,250 in tax deductions (Figure 5). Thus, PTC was the tax credit type that is more profitable for the solar energy company in Scenario 4 when compared to ITC.

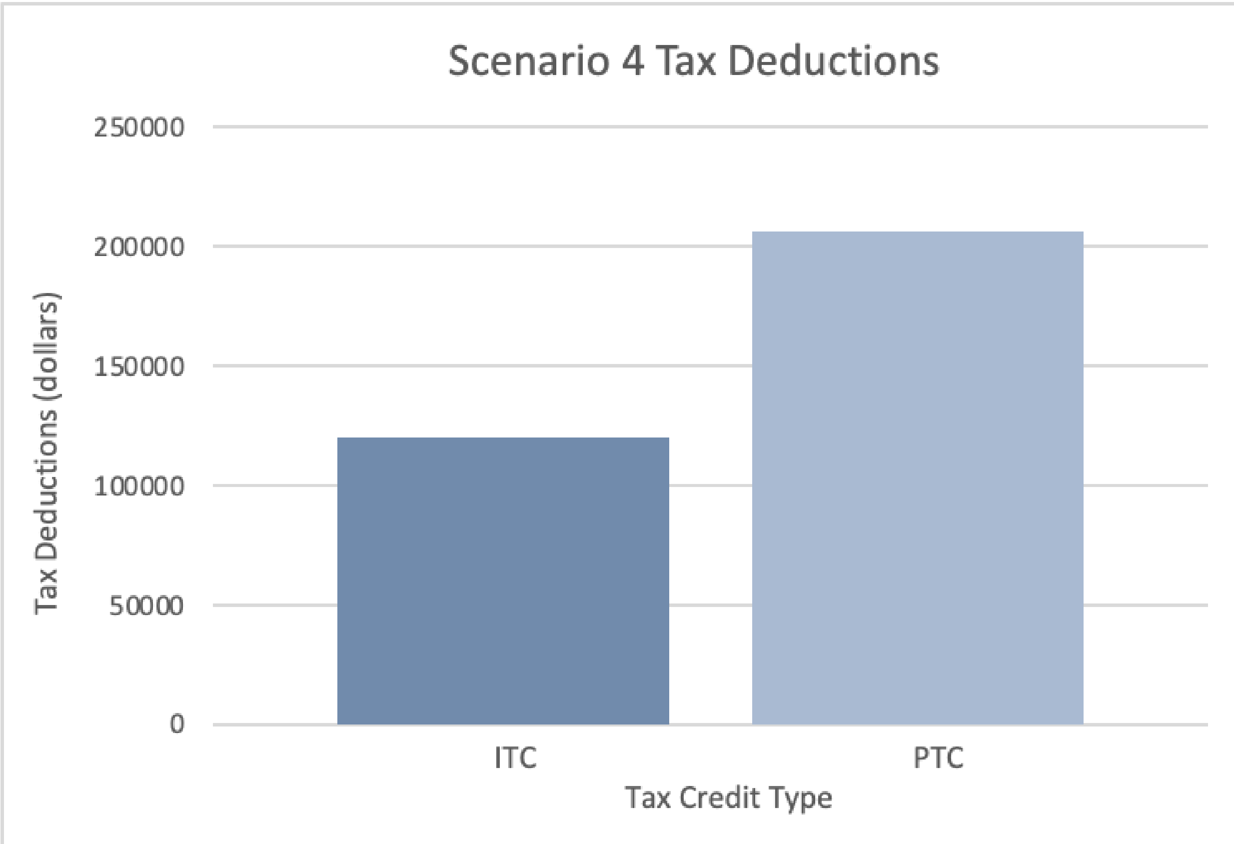


Figure 5. Tax deductions earned by the solar company from Scenario 4 for claiming either ITC or PTC values. The solar company would gain an additional $86K by claiming PTC tax credits, making PTC the more profitable credit option.

Lastly, Scenario 5 calculated for a ½ MW solar farm located in a sunny environment which provides average sunlight availability and is also classified as a qualified low-income economic benefit project. As a result of this classification, the project receives an additional 20% ITC (EPA 2023). Scenario 5's farm also requires an upfront cost of $400K to manufacture and install. Given the farm's plans to operate for 7 years, it would generate a total of 5,250 MW of solar electricity. Under these conditions, the solar company would receive a $200,000 decrease in their tax liability under ITC (Figure 6). Conversely, if the solar company instead chooses to claim PTC, it would receive $144,375 (Figure 6). For the example of scenario 5, ITC is the tax credit option that would provide greater financial benefit for the solar company.

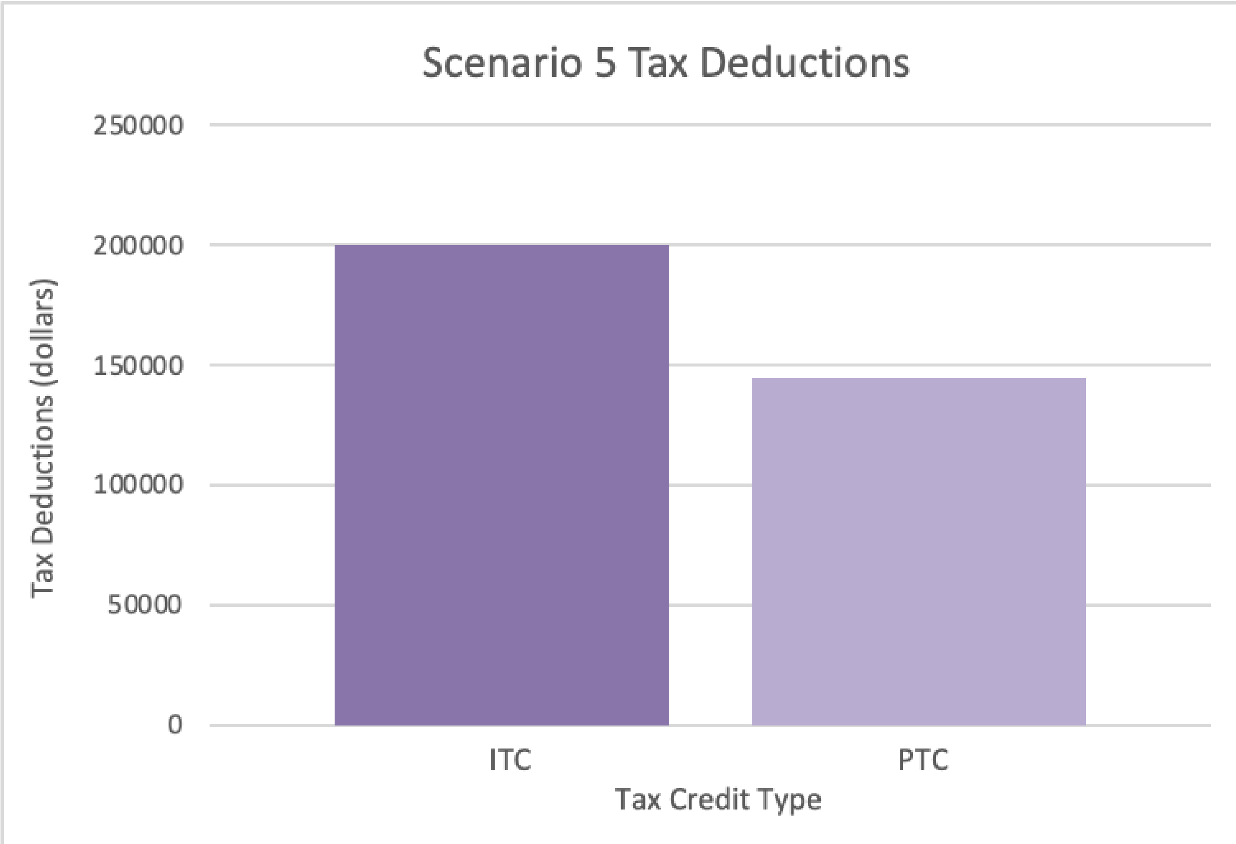


Figure 6. Tax deductions earned by the solar company from Scenario 5 for claiming either ITC or PTC values. The solar company would gain an additional $55K by claiming ITC tax credits, making ITC the more profitable credit option.

Business survey

In a survey of 50 different solar companies in the United States, the majority of companies hold a positive opinion about the IRA (Figure 7). Specifically, 32 out of 50 companies indicated a positive opinion of the IRA. The second most popular opinion regarding the IRA was no opinion in which I could not find a statement from a total of 12 companies about the IRA. Next, the third most acknowledged opinion regarding the IRA was neutral, held by 4 companies. Finally, the least common opinion that 2 solar companies have of the IRA is a negative opinion (Figure 7).

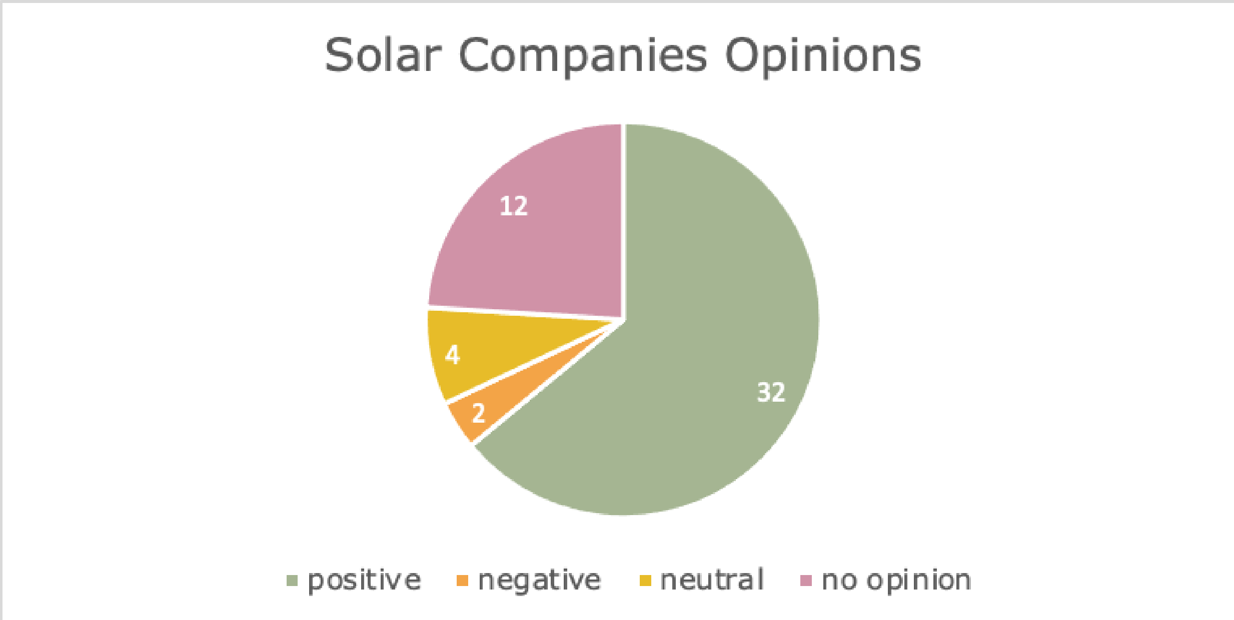


Figure 7. Results of solar energy company survey regarding the Inflation Reduction Act. The majority, 32, of solar companies hold a positive opinion of the IRA. The second most popular opinion of the Inflation Reduction Act was no opinion.

Positive opinions of the IRA praised the policy's ability to provide financial benefits, improve energy efficiency, and improve resilience against climate change. All positive statements listed financial benefits as the main outcome of the IRA's provisions for both homeowner and industry production and manufacturing which works to encourage renewable energy usage by making it more affordable. Most of these positive statements, specifically 19, additionally emphasized the financial benefits' ability to improve energy efficiency and thus solar energy generation due to lowered costs and greater levels of investment. Finally, 12 statements connected improved energy efficiency and reduced solar costs back to the global problem of climate change while celebrating the IRA's progress in lowering greenhouse gas emissions. Some major keywords used to categorize a statement as positive under these main indicators include:

- Focuses on how customers can "save" and receive financial "benefits" [29]
- Emphasizing how the IRA will help energy manufacturing achieve "critical growth" through "acceleration" [15]
- Establishing the Inflation Reduction Act as a "win" [10]

The minority of opinions held by solar energy companies were categorized as negative, neutral, or no opinion. The most common of this minority was a total of 12 solar energy companies that I could not find a public statement of opinion for. Next, 4 solar energy companies held an overall neutral opinion of the IRA; I categorized an opinion of neutral if the company described the IRA's positive and negative design attributes equally. The most common belief held by the neutral companies acknowledges that the IRA is the most significant renewable energy policy established federally but that its provisions and overall investment levels are still insufficient. Finally, the 2 companies who held an overall negative view of the IRA both briefly recognized the novelty of the IRA's initiatives but listed more negative impacts than positive. One complaint held in common by both companies is that the IRA's ability to accelerate renewable energy markets and thus increase demand will ultimately drive costs and slow production and manufacturing schedules.

DISCUSSION

My results suggest that given a larger budget and the ability to provide more tax credits, the Inflation Reduction Act has the potential to create unprecedented positive changes in renewable energy production. An assessment of the IRA's capacity to create benefits, both financial and environmental, for the U.S. paves the path for future environmental economic policies to receive adequate attention. As the United States' energy demands grow with their population, similar policies to the IRA that help companies and homeowners access renewable energy have to be a political priority. Proving the success of the IRA is one step that needs to be taken to provide policymakers with motivation to continue to support renewable energy production. While both production and investment tax credits can yield profit for solar companies, contrary to my prediction, production tax credits were shown to be overall more profitable to a larger variety of companies. In addition, given the overwhelming support of major solar energy companies for the IRA, future discussions of similar renewable energy tax credits need to be conducted. These results provide insight towards the currently unknown future of the IRA and what impacts it will have on renewable energy production, the environment, and the economy. It is important to demonstrate the positive impacts that the IRA will create because it encourages the development of additional environmental economic policies with strong funding.

Testing the relationship between tax credits and energy

According to my results, corporate tax credits have a statistically significant positive impact on industry energy production and investment that scales positively with the amount of credits offered (Figure 1). This conclusion suggests that policies that are capable of providing a larger amount of tax credits due to a larger budget will be more successful. The ARRA and IRA provided the same type of funding to the same category of company. Any differences in the outcome of funding or the number of renewable energy manufacturing facilities that received support can be directly attributed to the IRA's larger budget and consequent bigger funding capacity. In order for environmental policies to actually create significant changes on industry behavior and the health of the environment, these policies need to have substantial budgets.

My findings can be situated in the current state of budget policymaking in the United States's conflict on if federal budget changes should be more incremental or punctual equilibrium. Large-scale changes in policy designs, also commonly referred to as punctuated equilibriums, are growing a model of policy change that arose in the mid 1990s (Howlett and Migone 2011). As described in a research article on the failure of incrementalism, or the tendency of government policies to receive marginal budget adjustments over time, there are many instances where mandatory spending programs achieved success by doing the opposite; Medicare only received large budget increases over the span of 30 years and as a result almost doubled the the access to healthcare it provided (True 2000). While incremental budget changes help manage risk and have provided political balance in the past, equilibrium changes in policy and budgets represent opportunities for new policies and ideas to create an impact (True 2000). The success of the IRA follows the same path of Medicare where large shifts in budgets from the preceding policy are successful and create long-term benefits. In addition, the irregularity of national environmental policy, as shown by political events such as the United States' withdrawal and rejoining of the Paris Agreement in 2021, is a better fit for the inconsistency of punctuated equilibrium which is often attributed to institutional friction (Desmarais 2019). As the status-quo of moderate climate policy continues to change, progress will only be driven forward if environmental policies are allotted with notable funds instead of marginal additions.

Tax impact on profit model simulations

The five total tax impact model scenarios I ran suggest that production tax credits are more profitable for a wider variety of solar energy companies, as seen in Figures 3, 4, and 5. Because PTC provides a flexible tax credit that grows along with the scale of renewable energy production as compared to the ITC's more stable but lower rates, PTC will typically yield higher profits. The purpose of environmental economic policies such as the IRA are to help transition the U.S. towards a future of sustainability which includes renewable energy. In the long-term scale of the U.S.'s energy production where solar energy is a major contributor due to the presence of many large solar company facilities, PTC would be more financially beneficial. On the other hand, smaller scale projects that favor ITC would be helpful for less-used types of renewables in future policies that endeavor to expand renewable energy production beyond solar and wind. Furthermore, ITC projects are eligible for more bonus credits than PTC, such as the 20% ITC credit provided for qualified low income residential and economic benefit projects, that result in bigger profit margins (Figure 6).

While PTC offers a higher profit ceiling that provides a larger capacity for growth, it is hard to appoint it as the supreme option compared to ITC. Renewable energy sources have been known to be the more environmentally sustainable alternative to traditional fossil fuels for decades (Blakers et al. 2017). However, as previously discussed, their often larger upfront cost and need for investment is a substantial barrier to access. It is important for federal policy to address these barriers because the development and research of renewable energy cannot create positive environmental change if the technology is not being used. While renewable energy sources collectively have the capacity to decarbonize 90% of the nation's electricity usage by 2050, this shift will only be possible if renewable energy prices continue to fall (Osman et al. 2022). In a framework for the design and implementation of clean energy policy in the U.S, the first criterion of "access and availability" maintains that "any effective, renewable energy policy naturally delivers environmental benefits that are widely accessible and available" (Mormann 2018). Applying this framework to the IRA points toward the ITC as the more accessible option as opposed to PTC because any project regardless of their scale can participate and reap financial benefits.

Solar companies opinion survey

The solar company survey I conducted suggests that the majority of large solar energy companies in the United States view the IRA in a positive manner and have supported its policy development. These results are supported by other surveys conducted to assess the popular opinion of federal renewable energy policy. One study by the Pew Research Center found that "by sizable margins, Americans support a number of specific policy proposals aimed at reducing the effects of climate change through targeting greenhouse gas emissions and carbon in the atmosphere" (Tyson et al. 2023). The policy proposals included in the Pew Research Center's survey differ from the IRA's tax credits for energy production and investment, but still show that 76 percent support providing tax credits for businesses that develop carbon capture technologies (Tyson et al. 2023). Overall, my findings support the popular opinion that businesses in the U.S. should be encouraged to invest in renewable energy via federal policy incentives.

It is important to understand the support received by and the opinion of solar energy companies regarding the IRA because they are the parties directly affected by its implementation and the political power they hold. The current state of endorsement from the majority of leading renewable energy companies, as seen in Figure 7, can help support future sustainable policy endeavors. As renewable energy sources grow into system-wide technologies with improved costs and capacities driven by innovation, the timing and direction of their growth is still also controlled by political factors (Breetz et al. 2018). Furthermore, one study on the dynamics of American politics established that patterns of change in policy are possible when issues have an unchallenged and supportive perception that is backed by monopolies, interest groups, government agencies, or politicians which is able to overcome the typically conservative system of policy making (Baumgartner and Jones 1993). In addition, support from major renewable energy companies will need to include financial resources for the further development of energy policy because the transition towards renewable energy will only occur after reducing economic alliances with global fossil capital (Burke and Stephens 2018). Given the public support of the U.S. for developing renewable energy, additional advocacy from renewable energy companies that have lobbying and political power can help ensure the creation of future sustainable policy.

Limitations

The main limitations of this study lie in its use of predictive data to assess the capacity of the IRA which restricts the generalizability of my study questions. The purpose of my study was to create future predictions of the IRA's profit capabilities and to assess the policy's popularity because the policy was recently established and has not yet had a chance to generate its own data. My predictions of the IRA's impacts on renewable energy generations were based on a different policy, the ARRA, which originates from a different economic, social, and cultural period. My second subquestion's method of comparing ITC and PTC using simulations also creates limitations in my study's ability to confidently choose a better tax credit because my study is limited to 5 model simulations that do not represent all the possible different solar companies. Moreover, these simulations do not account for real life circumstances in solar energy production and investment including but not limited to inflation, seasonal changes in solar availability, wage and labor requirements, equipment delay or repairs, and property costs. In addition, my solar company survey only represents major companies as well as excluding other renewable energy types. As a result, this survey is not representative of the opinions of all renewable energy companies in the United States and only accounts for a limited sample size. Furthermore, the classification system I used to categorize the opinion of each solar company included measures I developed based on relative overall sentiment.

Future directions

Considering that this study assesses the capacity of the IRA using predictive and limited data, future research will be crucial in creating a substantial assessment of the policy's success. My assessment's use of predictive data from past policies leaves practical questions regarding the accuracy of which the IRA's success can actually be measured. Specifically, research that is conducted at least a decade into the future will be to use established data years after the IRA's ratification and provide a more confident assessment of the IRA's impact as compared to studies that are currently being conducted with limited or predictive data. Another gap that remains from my study's first subquestion is that my prediction of the IRA's capacity to impact renewable energy generation was only measured in terms of numbers of renewable energy manufacturing facilities. Because these results can not be generalized into an overall measure of renewable energy generation, future studies should aim to determine the specific changes in renewable energy generation that resulted from the IRA's establishment. In addition, my finding that PTC are more profitable for a wider range of renewable energy companies was concluded from simulations that may not reflect real profit scenarios. These more specific and detailed studies will create a more comprehensive picture of the IRA's success.

Broader implications

This study's affirmations of the IRA as a well designed and successful environmental economic policy holds significant implications for the development of similar federal policies for other types of renewable energy. Successful environmental economic policies will be a key tool in transitioning the United States to a renewable energy future by providing resources to make renewable energy technology more accessible and efficient (Dubois et al. 2019). The pressure to develop these policies grows every year as the threat of climate change continues to worsen and manifest on a global scale; In order to avoid irreversible damage to the Earth's ecosystem and human health, major changes in our national greenhouse gas emissions will be necessary and the IRA is just one piece of the puzzle (Macpherson 2014). The IRA is primarily focused on developing and providing access to solar and wind energy which excludes other rising forms of renewable energy such as bioenergy (Barbanell 2022). To further encourage the use and development of solar and wind energy while also promoting the growth of other types of renewable energy, it is important that environmental economic policies are a political priority. The success of the IRA is a step towards achieving this progress because if the IRA is shown to create profit and receives industry support, this encourages the development of more policies that can promote sustainability using similar economic strategies. As these strategies are established as profitable and stimulating, they open the door for the rest of renewable energy types to receive the financial and political support needed to permanently replace fossil fuels on a national scale.

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