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A new perspective on the U.S. energy efficiency: The political context

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ABSTRACT

This paper offers a new perspective on the energy efficiency literature by bringing evidence of political contextual factors as the predictors of energy efficiency. Specifically, we posit that the Democrat administration is more energy-efficient considering the reduction of environmental impact, in contrast, the Republican administration is more efficient considering only financial expenditures leading to the production of economic growth. In addition, we predict that political administration tenure is negatively correlated with green energy efficiency and that political distancing moderates the relationship between political party administration and energy efficiency. This study sheds light on these matters by performing an efficiency analysis of fifty North American states through a bootstrap DEA non-parametric model, followed by Tobit regressions to evaluate our hypotheses concerning the effect of the contextual factors on the calculated efficiency scores.

1. Introduction

Energy is a key resource for the production process in many economic sectors (Aye et al., 2018). In addition to being an input in the production process, energy is also a consumption good (Ewing et al., 2007). As the population and the economy grow, the demand for energy increases, which raises the concerns regarding not only the energy security, but also the environmental issues caused by CO_2 emissions (Aye et al., 2018). Consequently, as highlighted by Patterson (1996), energy efficiency as a policy matter is relevant to achieve economic, energy security, and environmental goals, including the reduction of CO_2 emissions.

Energy efficiency can be defined as "using less energy to produce the same number of services or useful output" (Patterson, 1996). Besides the benefits regarding the enhancement of energy independence and the reduction of carbon emissions, energy efficiency can also contribute to economic growth by, for instance, creating jobs (Wei et al., 2010). Therefore, given its potential implications, it is reasonable to assume that energy efficiency is a relevant subject to be investigated. Further, previous studies have applied energy efficiency to various specific contexts including South Africa (Aye et al., 2018), the Chinese industries (Li and Shi, 2014), the Indian manufacturing sector (Mukherjee, 2010) and the French households (Charlier, 2015).

Particularly, the United States represents a compelling setting to further analyze its energy efficiency, so that it has been the focus of other studies in this field (e.g., Adua, 2021; Dixon et al., 2010; Sovacool, 2009). This relevance may be attributed to the fact that the United States is an important consumer and producer of energy in the world, which suggests that any policy that affects the U.S. energy use will have an impact on the world energy market (Soytas et al., 2007).

In the present study, we propose to investigate the effect of several political indicators (e.g., political party tenure, political party administration on state and federal levels) on energy efficiency in the United States to provide an answer to the following research question: "Does the United States' political context influence energy efficiency at the state-level?". In addition, we will analyze the influence of other non-political contextual elements, namely, time (measured by year) and the GINI index, which measures the degree of deviation from the actual income distribution among individuals or households to the most optimal one (OECD, 2002). The narrowed focus on the state-level energy efficiency is justified by the fact that, besides the state dimension being neglected in the previous analysis, in the U.S., the states play a key role in the policymaking process (Adua et al., 2021).

More specifically to the U.S. political context, the Democrats are more inclined towards the social and environmental concerns that may lead to higher eco-energy efficiency (McCright and Dunlap, 2011; Coley

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and Hess, 2012) in contrast to the Republicans, who tend to be more economically driven regardless of the potential, environmental, and social harms (Coley and Hess, 2012). Therefore, we argue that compared to the Republican administration, the Democrat administration will have higher energy efficiency considering the reduction of the environmental impact and, in contrast, the Republicans will be more efficient than the Democrats considering only financial expenditures leading to economic growth. Moreover, we posit that political administration tenure is negatively correlated with green energy efficiency due to the entrenchment of the political agents (Cordero & Miller, 2019) and, lastly, we propose that political distancing (federal-level vs. state-level) will moderate the relationship between political party administration and energy efficiency.

We shed light on these matters by performing an efficiency analysis of fifty North American states between 1998 and 2014 through a bootstrap DEA non-parametric model, which will envelop our data (Aye et al., 2018) and allow for bias correction. The bootstrap procedure deals with the sample sensitivity issues, which often overestimate the efficiency scores. Subsequently, we applied Tobit regressions to evaluate our hypotheses concerning the effect of the contextual factors on the calculated efficiency scores, which censor the potential values that did not fit into the 0–1 range.

In the current research, we opted to calculate the energy efficiency through four different models: (1) Energy consumption and the state's expenditure as inputs, GDP as a desirable output and CO_2 emissions as an undesirable output; (2) Energy consumption as an input, GDP as a desirable output and CO_2 emissions as an undesirable output; (3) Energy consumption, the state's expenditure and CO_2 social costs in dollars as inputs, GDP as a desirable output; (4) the state's expenditure as an input and GDP as a desirable output. To deal with our CO_2 emissions, we have treated them as a regular input based on a methodological approach, which is widely used in the literature (Halkos and Petrou, 2019).

While the previous studies have addressed the influence of the political contextual factors on energy efficiency in general (e.g., Langlois-Bertrand et al., 2015) and applied specifically to the U.S setting (e.g., Adua, 2021; Adua and Clark, 2021; Gromet et al., 2013), to the best of our knowledge, there has not yet an empirical study that has thoroughly examined, using the non-parametric DEA models, how the Executive and Legislative branches of the U.S structure of power (i.e., president, governor, senate, house of representatives) influence energy efficiency measured by several models with different inputs and outputs, reflecting both economic growth and environmental preservation goals.

We expect to contribute to the literature on efficiency analysis by offering a new perspective regarding the influence of the contextual factors on the decision-making units' energy efficiency, more specifically, political predictors. In addition, we expect to bring forward public policy implications and insights concerning the improvement in energy efficiency in the United States at the state-level, the reduction in the environmental impact and the enhancement of energy security of the country. In other words, as stated by Adua et al. (2021), our proposed analysis represents a "good and robust opportunity to examine the depth of the partisan divide on environmental issues in the United States".

The remainder of this research is structured as follows: in Section 2, we describe the U.S. energy context in which our study is embedded, in Section 3, we review the existing literature on energy efficiency and develop the hypotheses, in Section 4, we describe the methodology, in Section 5, we report the results derived from our data analysis and lastly, in Section 6, we discuss our findings and address the limitations of the present study and viable future research avenues.

2. Contextual setting: U.S. energy

The United States is the second-largest energy consumer in the world with an annual consumption of about 101 quadrillion BTU of electricity, which represents 24 % of the global consumption (Energy Information Administration, 2018). The current data on the U.S. energy shows that the country relies on a mix of energy sources, including the primary sources such as fossil fuels (petroleum, natural gas, and coal), nuclear energy and renewable sources and the secondary sources such as electricity (Energy Information Administration, 2021c).

Four sectors are the end-consumers of energy produced in the U.S., namely the transportation, industrial, commercial, and residential sectors (Energy Information Administration, 2021c). The industrial sector, closely followed by the transportation sector, was the one with the highest amount of energy consumption in 2020. The sources of the energy consumed by each of these sectors vary among each other. For instance, in 2020, the predominant source of energy used in the industrial sector was natural gas (41 %), while in the transportation sector was petroleum (90 %), and in the residential and commercial sectors was electric power (43 % and 50 %, respectively) (Energy Information Administration, 2021c).

Not surprisingly, the U.S. also accounts for the world's second-largest CO_2 emissions of 5.41 GT per year, which represents 15 % of the global emissions (Union of Concerned Scientists, 2020). For this reason, climate change has become a major concern and increasing research efforts are being placed on energy efficiency (Allcott and Greenstone, 2012). In an empirical analysis of the United States, Soytas et al. (2007) found that CO_2 emissions are caused by energy consumption in the country, which points to the relevance of energy efficiency policies and an increase in the use of clean energy sources to reduce the environmental degradation.

Further, evidence suggests that the U.S is working towards improving its energy efficiency over the past decades (Granade et al., 2009). Specifically, the U.S. was the fourth most proficient country in diminishing CO_2 emissions relative to its real GDP growth rate from 2000 to 2005 (Dixon et al., 2010). It is also possible to observe a downward trend in the consumption of fossil fuels. In particular, the year 2020 had the lowest levels of petroleum, natural gas, and coal consumption in the country since 1991 and the largest annual reduction of CO_2 emissions since 1949 (Energy Information Administration, 2021d). Additionally, in the same year, the energy derived from non-fossil fuels sources, including nuclear and renewable sources, achieved 21 % of the country's total consumption, which represents the highest proportion since the beginning of the 20th century (Comstock, 2021), reinforcing the decline of fossil fuels usage.

In parallel, although it is important to highlight that a transition towards renewable energy is inevitable given the imminent exhaustion of fossil fuels resources (Vachon and Menz, 2006), a growing tendency in the consumption of renewable energy sources such as wind, solar and biofuels is also happening in the U.S, having achieved 11 % of the country's total energy consumption in 2019 (Energy Information Administration, 2020).

The total energy consumption in the U.S, depicted in Fig. 1, illustrates the above-mentioned growing trend in renewable energy sources and the decreasing consumption of coal, a highly distributed fossil fuel inherently related to greenhouse gas emissions (Balat, 2007). The coal consumption in the United States has been reduced to less than its half

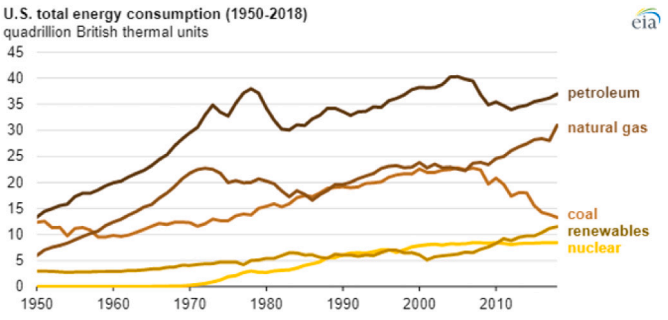

Fig. 1. U.S total energy consumption by source (U.S. Energy Information Administration).

since the highest level in 2005, having achieved its lowest degree in 2020 compared to the one of the past 116 years (Comstock, 2021).

We can observe from the graph that both of these trends start after the year 2000 and are more pronounced closer to the 2010 threshold, which is possibly related to the Barack Obama's election in 2009, whose administration proposed "federal mandates for greenhouse gas emissions, national renewable electricity standards, and new federal investment in clean energy infrastructure" (Dixon et al., 2010), this demonstrates the federal government's support to the climate change-related legislation (Coley and Hess, 2012).

Moreover, the COVID-19 pandemic affected the energy sector in the United States in a relevant manner. Specifically, in the year of 2020, physical restrictions, which are mandatory in several states, contributed to a decline in the demand for transportation fuels and in the fuel prices (Energy Information Administration, 2021a). Therefore, among other factors, the COVID-19 pandemic was responsible for a dramatic reduction in energy consumption in the U.S, which was accounted as the largest annual reduction on record (Comstock, 2021). The 2021 Annual Energy Outlook indicates that several years will be needed for the energy consumption to return to its level as it was in 2019 and this recovery remains embedded in uncertainty (Energy Information Administration, 2021b).

3. Literature review and hypothesis development

3.1. Energy efficiency

Energy efficiency can be measured by a simple ratio between the outputs and inputs in the process of energy use (Patterson, 1996). At aggregate levels, energy efficiency can be measured as "the level of gross domestic product per unit of energy consumed" (Gillingham et al., 2009). Indeed, the most common measure to assess a country's energy efficiency is the ratio between the energy input measured in thermodynamic units and the output measured by market value (GDP; Patterson, 1996). However, the existing literature has empirically investigated energy efficiency through multiple methodologies across different contexts.

Previous studies in the field have addressed the impact of gubernatorial and managerial policies in the community on quality of life and climate change. For instance, Nabavi-Pelesaraei et al. (2017) evaluated both the energy consumption and the environmental impact of incinerating and landfilling municipal solid waste (MSW). They concluded that the energy generated by the incineration of MSW reduces the release of toxic factors. However, the authors also identified that landfilling is preferred financially, despite the waste reduction and environmental benefits encountered in the previous scenario. Moreover, Nabavi-Pelesaraei et al. (2021) analyzed the exergoenvironmental efficiency for using solar technologies in the sunflower oil production in Iran, comparing the present scenario with the photovoltaic and the hybrid photovoltaic/thermal power plants scenarios. Their findings suggest that the photovoltaic scenario displays the lowest rate of damages to human health, ecosystem quality, climate change, and resources.

The literature also examines the aftereffects of energy inefficiency on strategic policies and the environment. Shabanzadeh-Khoshrody et al. (2016), for example, compared the efficiency on agricultural production among groups of farmers who used water from distinct sources. The results indicate that the group of farms using the Baft dam's water source had higher efficiency due to scale efficiency. Therefore, in this case, besides the benefits of using a renewable source of energy, this enterprise also had a positive impact on the local community (Shabanzadeh-Khoshrody et al., 2016). Regarding the efficiency optimization, Khanali et al. (2021) investigated the energy use efficiency and the consequent emissions of walnut production in the context of the Alborz province of Iran. While the authors identified inefficiency in the walnut orchard, they indicate that the timely maintenance such as oil change and air filter replacements could significantly increase the walnut production energetic efficiency aligned with personal training; thus, attenuating the environmental impact (Khanali et al., 2021).

Lastly, Gromet et al. (2013) demonstrated that political affiliation may affect individuals' attitude towards energy efficiency. Specifically, the conservative individuals are less favorable to the energy-efficient technology and less likely to purchase more expensive energy efficient products compared to their liberal counterparts. Along the same lines, in our research, we intend to investigate how political parties impact energy efficiency in the US at the state-level. In the next section, we review the literature on the comparison between the liberal and conservative ideologies and their policy implementations, as well as the reason it may represent a significant agent fostering (or undermining) energy efficiency in the US.

3.2. Republican and Democrat political ideologies

The Republicans and Democrats are pronounced by diverging opinions regarding the role of the government in response to social issues. While the Republicans advocate limited government intervention, free-market economy, and private property rights, The Democrats advocate market regulation, social service provision, collective welfare, and governmental intervention for protecting the underprivileged citizens. Moreover, The Republicans tend to rely on system justification theory, while the Democrats are more open to disruptions of the *status quo* (McCright and Dunlap, 2011).

Besides the polarization between Republicans and Democrats, contrasts among liberal and conservative ideologies are also likely to reflect the political and policy preferences (Morris, 2020). Smith (1990) posits that the contemporary liberalism in the U.S. is characterized by an opposition towards the status quo and favoring of change, democratic rights, civil liberties (e.g., free speech and protest), intervention and regulation of the State on the economy and on local governments, humanitarianism, and egalitarianism. Conversely, the conservatism tends to be favorable towards the maintenance of social traditions, citizen protection, social hierarchy, harsh punishments, and military investments (Morris, 2020). Therefore, we can conclude that the Democrats are mostly oriented towards liberal principles, in contrast to the Republicans, who are in line with conservative, right-wing and business-related views (Coley and Hess, 2012; Morris, 2020).

The political ideology was proven to influence the attitude and behavior of individuals. More specifically, regarding the context of environmental protection, the political ideology was found to be one of the main motivations for engaging in this issue. In the United States, while the environmental concern is part of the liberal ideology, the conservatives tend to disregard such concern (Gromet et al., 2013). For example, Chandler (2009) found that the liberal government ideology was positively associated with the adoption of Sustainable Energy Portfolio Standards (SEPS), which encompasses both renewable and energy efficiency standards to stimulate the transaction into clean energy use. Similarly, the empirical findings from the U.S. indicate that political interests play a significant role in the adoption of state-level green energy measures (Vachon and Menz, 2006). Furthermore, the environmental protection poses a conflicting issue for the conservative ideology as it involves governmental interventions and regulations of market and property rights, this is consistent with the liberal ideology as it protects collective welfare (McCright and Dunlap, 2011).

The Republicans have a history of opposition towards green energy laws, which is contrasting with the Democrats' consistent support to this type of legislation (Coley and Hess, 2012). Hence, it is reasonable to assume that the Republican citizens and governments are less likely to be concerned with the environmental issues, which might influence the Republicans' willingness to support an environmental agenda (Adua, 2021). Corroborating evidence supports that the Republicans are mostly interested in economic growth to the detriment of relevant environmental issues, specifically, the U.S. states with strong fossil fuel industries were negatively associated with the Republican's support to the

green energy laws (Coley and Hess, 2012). Comparably, Adua and Clark (2021) indicate that the Republicans (or the conservatives) tend to be less connected to the environmental issues for several reasons, including their resistance towards social changes, which is a necessary step in applying the environmental protection policies, and their inclination to favor business over social goals (Adua and Clark, 2021). Further, previous findings show that the Republicans' willingness to support green energy policies is lower when the Democrats' proportion in the legislative chamber is higher, in other words, the Republicans' endorsement of these policies increases when they have dominance over their legislature and when the liberal ideology is not predominant within their state (Coley and Hess, 2012).

On the other hand, energy efficiency, despite being mostly tied to an environmental protection public discourse, also entails economic-related advantages, including stimulating industrial production and reducing the costs per unit of energy produced, which raises the question of whether the Republican or the Democrat administration would have a higher commitment to this matter (Adua, 2021). This debate is related to the possible existence of the political-institutional barriers to energy efficiency (Langlois-Bertrand et al., 2015). A practical example is a political obstruction to the fuel efficiency regulation in the U.S, which commonly entails the adoption of fuel taxes and specific standards (Langlois-Bertrand et al., 2015). The efforts to impede such measures mostly come from the Congress and the House of Representatives and are driven by, among other factors, political ideology (Langlois-Bertrand et al., 2015). Particularly, the administration of the former U.S president Barack Obama, who was a member of the Democrat party, adopted stricter standards regarding car-driven carbon emissions (Langlois-Bertrand et al., 2015), which suggests lower political obstruction to the energy efficiency policies by the Democrats.

The empirical findings indicate that the Republicans' opposition to the environmental policies exceeds the economic benefits connected to the enhancement of energy efficiency (Adua and Clark, 2021). For example, the previous results have shown that the Republican party governments are associated with a decrease in the states' energy efficiency policy scores, in other words, the states ruled by the Republicans are less likely to adopt energy-efficient measures (Adua, 2021). Similarly, further research has concluded that the U.S states' political ideology can help shape the adoption of measures and policies related to energy efficiency, specifically, the states with the Republican administration are associated with lower utility energy efficiency scores, which leads to the conclusion that the states ruled by the Republican political ideology create fewer incentives towards the utilities' investment in energy efficiency (Adua and Clark, 2021).

An aspect that helps to explain why the Republican state governments tend to be less energy efficient is the fact that the energy-related policies require regulatory measures, which clashes with the Republican's convictions against government expansion (Adua, 2021). An alternative account proposes that the Republican's opposition towards the green energy laws is strategically aimed at undermining the Democratic presidential government's popularity, while also portraying this legislation in a negative light by associating it with an extreme financial burden (Coley and Hess, 2012). Based on the presented evidence, we argue:

Hypothesis 1. The Democratic administrations (vs. the Republican administrations), are more efficient in a green energy policy, considering economic growth and engendering lower environmental and social costs as outputs.

Hypothesis 2. The Republican administrations (vs. the Democratic administrations), in contrast, are more efficient in economic development considering only financial expenditures as an input and economic growth as an output.

3.3. Political tenure

Political tenure is the period between a political appointee's confirmation and the succeeding political appointee's nomination, in other words, it is the length of a politician's time in office, which can be the duration of one or more terms (Chang et al., 2001). Some researchers argue that the politicians that hold office for two terms, present lower levels of stress in the second term, as they are more experienced, more confident, and are not under the pressure of re-election, and consequently, are better decision-makers, and are more committed to a successful implementation of policies (Yang et al., 2018).

Although a long political tenure may be seen as positive given that the politicians have more time to implement new policies and resolutions and face lower stress levels, a contrasting argument states that a long political party tenure may be detrimental. For instance, a long political party tenure is a favorable scenario for political entrenchment, which in turn may trigger lower government responsiveness and higher government corruption. Precisely, the longer a political party's tenure, the greater the chances of incumbency advantages, such as stronger relationships with influential groups, greater prominence in the electorate's mind, and greater probability of the party remaining in power in future elections. Such incumbency advantages are propitious for political entrenchment, the situation in which the politicians use their power to benefit themselves instead of the nation, and consequently, is less responsive to the nation's needs and government bureaucracies, leading to a decreased efficiency, and potentially, government corruption. (Cordero & Miller, 2019). Thus, based on this background and rationalization, we propose:

Hypothesis 3. Political administration tenure is negatively correlated with green energy efficiency.

3.4. Levels of power in the United States

The United States' Constitution determines that the power is divided into three different branches, the legislative, the executive and the judiciary, which are assigned to the Congress, the President, and the judges, respectively (Currie, 1985). In other words, the distribution of power is such that “Congress must pass a law, the President must seek to enforce it, and the courts must find a violation” (Currie, 1986).

In the U.S. system, the Senate and the House of Representatives jointly compose the U.S. Congress (United States House of Representatives, n.d.-a, n.d.-b) and are responsible for making the State laws (The White House, n.d.). The House of Representatives is composed of no more than 435 voting representatives (number fixed by law since 1911) that proportionally represent the population of all fifty states and hold the power of making and passing the federal laws. Each representative is elected to serve a certain congressional district by introducing the bills and resolutions, proposing amendments, and serving on committees (e.g., agriculture, natural resources, climate crisis, technology), for a two-year term (United States House of Representatives, n.d.-a, n.d.-b).

The U.S. Senate is composed of one hundred members, two senators for each of the fifty states that serve six-year terms and hold distinctive powers, duties, and responsibilities (United States House of Representatives, n.d.-a, n.d.-b). This chamber is considered a unique and autonomous political institution due to its composition of powers and purposes (Wirls et al., 2004). Among its distinctive duties are approving or rejecting international treaties, attesting to the validity of the President's appointments to the country's courts and performing jury duties while conducting a trial in the case of the President or a member of the Supreme Court being impeached (Arnold, 2004). Volden and Wiseman (2018) argue that due to the Senate's notable functions such as taking part in the making of laws and the governing process in the U.S., the chamber has been the home of many future candidates for the federal presidency.

Although the Senate and the House of Representatives have equal

influence in the lawmaking duties (Volden and Wiseman, 2018) and "are granted nearly equal powers" (Wirls et al., 2004), the Senate and its senators are seen as more dominant over this matter (Volden and Wiseman, 2018). This perception may be attributed, among other factors, to the fact that the senators serve a longer term and, therefore, accumulate more policies that affect the state as a whole (Volden and Wiseman, 2018) and to the fact that the Senate has a higher proximity to the executive power by having a say in the appointments to the judiciary (Volden and Wiseman, 2018; Wirls et al., 2004).

In addition to the Congress, within each state in the U.S., there is an elected governor that represents the Executive branch (The White House, n.d.) and is responsible for managing the daily operation of the government, conducting the laws and supplying the services (Arnold, 2004). In summary, the Governor (Executive branch) and the Congress (Legislative branch), along with the state courts (Judiciary branch), represent the State Government (The White House, n.d.), which is independent of the federal government given the sovereignty of the states in the United States (Arnold, 2004).

Another level of power within the United States is represented by the local governments, which are composed of counties and cities (or municipalities) (Arnold, 2004; The White House, n.d.). These governments are led by the elected members and are responsible for services that include public transportation, public safety and the maintenance of streets and parks (Arnold, 2004). The empirical evidence supports that, at the local level, the political parties, that is, whether the mayor belongs to the Democrat or the Republican party, do not have an influence over policy-related issues, including city government size, crime rates and allocation of public resources (Ferreira and Gyourko, 2009). Furthermore, while the federal and state governments are accounted for in the Constitution (Arnold, 2004) and share power, the local governments need to have power conceded to them by the State (The White House, n.d.). Based on this reasoning, we opted to focus only on the federal and state levels of power due to our object of study being energy efficiency, which closely depends on government decisions.

With regards to the enactment of public policies, the federal, state, and local government powers share the role of crafting policies in the U.S. system, therefore, the states can implement policies, such as energy-related policies, on their own or with the federal sphere's support and participation (Adua, 2021). Historically, the implementation of energy efficiency measures by the U.S. states, irrespective of the Congress, has served as an incentive for the market participants to claim for the follow-up national policies in the Congress (Dixon et al., 2010). Adua et al. (2021) indicates that previous research has found that local governments have implemented measures focused on environmental issues, including energy policies, which had been disregarded by the federal sphere. Similarly, the U.S. states also craft policies regarding the issues previously ignored by the federal government (Adua et al., 2021).

The empirical evidence indicates that the engagement in environmental causes is highly driven by political partisanship at all three levels of the government in the U.S.: federal, state, and local (Adua, 2021). Additionally, Vachon and Menz (2006) point to the existence of distinct foci regarding energy policies across various levels of power in the U.S., specifically, "while policies of the federal government have focused on financial production incentives and grants to promote research and development in renewable energy technologies, the state governments have adopted a wider array of policies".

For this study, we define political distancing as the various levels of policymaking, specifically, the state level and the federal level. Therefore, when the State authorities' political party (i.e., senators, governors, and house representatives) is the majority within their state, we consider it as a low level of political distancing, on the other hand, the federal-level majority is considered as a high level of political distancing. More specifically, we argue that when the Democrat senators and house representatives are governing towards the state level, they will prioritize environmental policies and energy efficiency measures focused on the reduction of CO_2 emissions. In contrast, when these authorities are governed with the federal interests in mind, they will tend to favor economic goals, which will reduce eco-energy efficiency.

Hypothesis 4. Political distancing moderates the relationship between the Democratic Party administration (vs. the Republican Party administration) and green energy efficiency. Specifically, at high levels of political distancing, the correlation between the Democratic Party administration (vs. the Republican Party administration) and green energy efficiency is weaker.

4. Methodology

4.1. Data

To calculate the political parties' efficiency scores, we collected the data from fifty states in the United States of America from 1998 to 2014, forming a total of 850 state-year observations. The variables included Real Gross Domestic Product, Total carbon emissions, State expenditures, and Total energy consumption. Although the efficiency scores are mathematically weighted in the DEA method, they rely on inputs and outputs, in which researchers actively arbitrate in the selection process. Moreover, according to Halkos and Petrou (2019), it is a challenge to deal with undesirable outputs and there are at least four ways to treat them: (i) ignoring them from the production function, (ii) treating them as regular inputs, (iii) treating them as normal outputs and (iv) performing necessary transformations to take them into account. For instance, in the energy efficiency literature, CO_2 emission is considered an undesirable output (Hadi-Vencheh et al., 2020; Iftikhar et al., 2018). Nonetheless, many authors have already treated them as a regular input to generate the DEA's efficiency scores (Gomes and Lins, 2008; Oude Lansink and Bezlepkin, 2003). In our study, we opted to treat our DEA model using the CO_2 emissions variable as a regular input because the model would increase the score of DMUs who minimize their pollutants, this is methodologically coherent. To address with this degree of freedom that the researchers have in establishing which variable to include and in defining how to apply them in their model, we devised four distinct models for the purpose of increasing the validity and providing robustness of our study. Our models' constituents are present in Table 1.

Model (I) covers all the attributes from the collected data in their original measurement unit. Model (II) is centered only on economic

Table 1
Energy efficiency models

Main efficiency model (I)
• Inputs: total energy consumption (BTU) + state expenditures (US dollars). • Output: real GDP. • Undesirable output: CO_2 emissions (metric tons).

Eco-efficiency model (II)
• Inputs: total energy consumption (BTU). • Output: real GDP. • Undesirable output: CO_2 emissions (metric tons).

Social cost and energy efficiency model (III)
• Inputs: total energy consumption (BTU) + state expenditures. • Output: real GDP. • Undesirable output: CO_2 converted to US dollars

Financial efficiency model (IV)
• Input: state expenditures (US dollars). • Output: real GDP.

growth and the environmental harnessing inputs, disregarding the states' expenditures from the analysis. Model (III) reproduces model (I) by converting CO_2 emissions in metric tons to the current consensual US carbon social cost value (Ricke et al., 2018) aggregated with the states' expenditures; thus, devising a new attribute, total cost, as an input. In contrast, model (IV) considers only the state's expenditures and real GDP, limiting the scope of the analysis only to the financial perspective. Thus, for sake of simplicity, we refer to models (I), (II), and (III) as eco-efficiency models, given that they compute energy efficiency by adopting the environmental harnessing inputs and outputs.

Additionally, we gathered the data on Gini coefficient as a contextual variable. The relationship between Gini coefficient and the efficiency scores is twofold. On the one hand, the level of equality increases broader access to more efficient technology, which, in turn, reduces resources use and increases wealth generation. On the other hand, it may lead to higher consumption and, subsequently, produce higher emissions of CO_2 (Dinda, 2004). Concerning GDP, the literature points to diverging directions. For instance, the seminal work of Kuznets (1955) posits that in the short-term, economic growth engenders income inequality, then, in the long term, the inequality levels narrow down. Alternatively, Piketty (2014) argues that the inequality decrease observed from 1914 to 1950 was derived from specific shocks, for example, the world wars and the great depression, and that the inequality has an upward and exponential trend under the capitalism doctrine, according to the existing data on the date of the publication. Based on any of the possible assumptions, it is reasonable to claim that this variable has a substantial influence on the eco-energetic efficiency scores.

Concerning the political parties, we gathered the data from the elected president and governors' political parties. Also, we recorded the political party that had the majority seats in the Senate and the House of Representatives in the federal and state levels. Therefore, as our treatment variables, we have, at the state level, the governors, Senate, and House of Representatives elected political party, and, at the federation level, we have the presidents, Senate, and House of Representatives elected political party for each state-year observation. Moreover, since the political agenda demands some implementation time and endeavor continuity, we added a tenure variable for each of the elected political agents in each political sphere.

4.2. Method

We accessed the political parties' efficiency scores with a bootstrapped Data Envelopment Analysis (DEA) in the first stage and, in the second stage, regressed them with the Tobit regression method. The DEA efficiency analysis developed by Charnes et al. (1978) is a well-established nonparametric method for the estimation of the frontier formed by the best practice Decision-Making Units (DMUs). It has been observed that a growing number of studies have adopted this technique and consistent efforts have been made to improve the method from different perspectives (Wang et al., 2016; Fei and Lin, 2016; Emrouznejad and Yang, 2018; Zhu et al., 2021). From the available DEA methods (Cook and Seiford, 2009), we chose the two-stage bootstrapped DEA-Tobit regression because: (i) the DEA efficiency scores do not suffer from the multicollinearity issues; thus, enabling us to analyze the correlated variables; (ii) the bootstrap procedure removes the potential bias from DMUs benchmarking – further detailed in the next sections; (iii) the Tobit regression limits the unbiased efficiencies scores to the range of 0 to 1, censoring the over- and under-efficient scores, if any, in the analysis; (iv) This two-step method has already a solid use and acceptance in the literature as a valid method in contrast to recent method variations (Hoff, 2007).

4.2.1. Data envelopment analysis (DEA) procedures

We conducted the bootstrapped DEA efficiency scores analysis through the package "rDEA" from the R software developed to implement the Simar and Wilson's (1998) bias-correction of technical efficiency scores in the input- and output-oriented DEA models. Based on the understanding that our inputs (CO_2 emissions, States' expenditures, Energy consumption) do not have linear returns to scale towards our output (Gross Domestic Product), we adopted the convex efficiency frontier, allowing variable returns to scale in the analysis (Banker et al., 1984). Moreover, we selected the output-oriented technique given that we have just the same output in all the devised models, whereas the inputs variables vary from one model to another in our study.

The output-orientated DEA posits that each *i*th DMU output vector expands radially until the DMUs inputs and outputs configurations form the best practice benchmark relative to the available sample. The benchmark derives from the minimum convex curve, which envelops all the inputs and outputs of the possible weighted configurations. Therefore, a sample with n DMUs containing K outputs, I variable inputs, determine the ith DMU's maximum output according to the following equation (Hoff, 2007):

$$\mu \mathrm{i}$$

$$s.t. \mu_i{}^* \Upsilon_{k,i} \leq \sum_{j=1}^{n} \lambda_{j,i}{}^* \Upsilon_{k,i} \forall k \, \epsilon \, \{1, \ldots K\},$$

$$\alpha_{v,i}{}^* \chi_{v,i} \leq \sum_{j=1}^{n} \lambda_{j,i}{}^* \chi_{v,j} \forall k \, \epsilon \, \{1, \ldots I\},$$

$$\sum_{j=1}^{n} \lambda_{j,i} = 1$$

$$\lambda, \alpha \geq 0 \tag{1}$$

where $\gamma_{k,i}$ and $x_{v,i}$ are, respectively, the kth output and vth variable input of the ith DMU. The factor v_i is the expansion factor for the vth variable input of the ith DMU. As mentioned before, the DEA weights "λ" ensures the variable returns to scale. The factor μ_i is the maximum output amount of the ith DMU. The efficiency score is obtained by:

$$\Theta_i = \frac{1}{\mu i} \tag{2}$$

4.2.2. Bootstrap bias correction procedures

One of the main criticisms towards the DEA method is that the results are potentially sensitive to the proposed sample. Another caveat is that the efficiency scores derived from this method are often overestimated. The observed best practice frontier, in the best scenario, can only resemble the practical or the theoretical one. Hence, the reference DMUs would always render an upward bias to the observed efficient scores given that the benchmark was devised based on a subsample of the actual or hypothetical efficiency idealization. Although large samples might significantly deal with the issue of overestimation, the multi-inputs/outputs DEA research must apply the bootstrap procedure given that no expression may produce the bias-corrected estimates (Staat, 2006). The Bootstrap procedures resampling the original dataset a given number of times to correct this potential upward bias. The DEA efficiency scores are calculated for each simulated dataset to form the confidence interval of the estimates. This procedure deals with the sensitivity issue to the sampling variations, which engenders the benchmark frontiers by mimicking the sampling distribution of the estimators (Simar and Wilson, 1998). In our specific study case, we gather the data from all possible DMUs of our analysis scope, which, theoretically, is already enough to validate our results towards the political parties' comparison in the selected period without the bias-corrected efficient scores. Nevertheless, this procedure makes the results of our analysis more conservative since it considers a hypothesized higher best practice frontier in comparison to the original ones, and the robust and accurate results can be generalized to other contexts.

4.2.3. Tobit regression models

The Tobit method regresses the dependent variables clustered within

a determined range, in which its corner values would represent the measurement boundaries in the data sample. This method regresses the equation by removing the upper- and lower-limit of the data from the analysis, eliminating the imprecision bias from the coefficient estimates. In our specific case of study, our bias-corrected efficiency scores may contain the values below 0, which are derived from the eliminated bias of the DMUs with extremely poor efficiency scores. Although this occurrence is atypical, large samples may significantly increase their occurrence rate. The main issue is related to the theoretical meaning since the efficiency scores with a value 1 represent perfectly efficient DMUs and the efficiency scores with a value 0 represent perfectly inefficient DMUs, while the values below 0 and above 1 do not have any conceptual meaning and, for this reason, must be eliminated from the analysis.

To cover the state and federal level of political party influence in the eco-efficiency administration, we devised three models to represent the spheres of political influence: (i) the state-level political sphere; (ii) the federal-level political sphere; and (iii) the joint state- and federal-level political spheres. Additionally, we regressed both the simple effect model and the model of each political agent interacting with their respective tenure period. We depict the regressed equations models as below:

A) State-level political sphere

$$\Upsilon_{i,t} = \beta_0 + \beta_1\chi_{i,t} + \beta_2\alpha_{i,t} + \varepsilon \quad \text{(I)}$$

$$\Upsilon_{i,t} = \beta_0 + \beta_1\chi_{i,t} + \beta_2\tau_{i,t} + \beta_3\rho_{i,t} + \beta_4\alpha_{i,t} + \varepsilon \quad \text{(II)}$$

where $\gamma_{i,t}$ is the bias-corrected efficiency scores, $X_{i,t}$ is a vector containing dummy variables representing elected political party agent of each state (Democrat party governor, independent party governor, democrats controlling the majority of the state's senate seats, democrats controlling the majority of the state's house of representatives seats), $\tau_{i,t}$ is a vector of the tenure of the political party in each political position, $\rho_{i,t}$ is a vector with the interaction terms of each political agent party and the respective tenure of the party in the political position, and, finally, $\alpha_{i,t}$ is the vector containing the contextual and control variables for each ith state and tth year. $\beta 0$ is the intercept, $\beta 1 \ldots \beta n$ are the unknown estimates' coefficients, and ε is the error term.

B) Federation-level political sphere

$$\Upsilon_{i,t} = \beta_0 + \beta_1\chi_{i,t} + \beta_2\alpha_{i,t} + \varepsilon \quad \text{(III)}$$

$$\Upsilon_{i,t} = \beta_0 + \beta_1\chi_{i,t} + \beta_2\varsigma_{i,t} + \beta_3\pi_{i,t} + \beta_4\alpha_{i,t} + \varepsilon \quad \text{(IV)}$$

where $\chi_{i,t}$ is a vector containing dummy variables representing the elected political party agent at each federal level (Democrat party president, democrats controlling the majority of the US Senate seats, democrats controlling the majority of the US house of representatives seats), $\varsigma_{i,t}$ is a vector of the tenure of the political party in each political position, and $\pi_{i,t}$ is a vector with the interaction terms of each political agent party and the respective tenure of the party in the political position for each ith state and tth year.

C) Joint state- and federation-level sphere

$$\Upsilon_{i,t} = \beta_0 + \beta_1\chi_{i,t} + \beta_2\chi_{i,t} + \beta_3\alpha_{i,t} + \varepsilon \quad \text{(V)}$$

$$\Upsilon_{i,t} = \beta_0 + \beta_1\chi_{i,t} + \beta_2\chi_{i,t} + \beta_3\tau_{i,t} + \beta_4\varsigma_{i,t} + \beta_5\rho_{i,t} + \beta_6\pi_{i,t} + \beta_7\alpha_{i,t} + \varepsilon \quad \text{(VI)}$$

Since we have a total of four models for the efficiency analysis and six Tobit regression models, in this study, we conduct a total of twenty-four models. Hence, our results have a robust explanatory power, and it is possible to parse out the distinct phenomena that might interact with each other, through which to provide more clarity to the analysis.

5. Results

The results from the bootstrapped Tobit regressions support our hypotheses, except for hypothesis three related to the tenure variable, in which we obtained mixed results. Although the evidence for the main effect is weak, when we interact the political agents' party with their tenure period, the results gain robustness and are in accordance with our predictions. The gap between the main effect and the interacted effect derives from the necessary time for the implementation of the political parties' agenda. Additionally, the policies' effects have inertia, which lasts even if the opposing party takes control over the political position. The interacted term gives weights to the efficiency scores according to the continuity of the political agenda, which is helpful to remove significant bias of our analysis. Hence, as initially envisioned, we consider the interacted models the most accurate and precise for capturing the efficiency performance comparison among the political parties' administrations. Henceforth, we will focus the discussion only on these results. Nonetheless, we present all the findings as below (also depicted in Table 2):

A) State-level analysis

The models (I), (II), and (III), which consider the environmental impact on the efficiency calculations, had all coefficients non-significant for political agents: governors, senate majority, and the house of representative's majority. Considering the model (IV), which is a financial-focused input and output approach, it suggested that the Democrats are less efficient than the Republicans ($\beta = -0.013$, $p < 0.01$).

B) Federal-level analysis

The Democrat Senate had a significantly positive effect in the models (I), (II), and (III) with the same coefficients and significance levels ($\beta = 0.036$, $p < 0.001$). Alternatively, the Democrat Senate had a significantly negative effect on the efficiency scores in the model (IV) ($\beta = -0.025$, $p < 0.001$). The Democrat majority in the House of Representatives and the democratic presidency administration had, respectively, significantly negative and significantly positive effect on the efficient scores in the model (IV) ($\beta = -0.022$, $p < 0.001$; $\beta = 0.017$, $p < 0.001$).

C) Joint state- and federal-level analysis

The joint political sphere bootstrapped Tobit regression replicates the finding of the isolated regression analyses, except for the Model (IV)'s Democrat Senate in the state-level analysis. Considering the models (I), (II), and (III), only the federal-level Democratic Senate had significant coefficients (Models (I) and (III): $\beta = 0.035$, $p < 0.001$; Model (II): $\beta = 0.036$, $p < 0.001$). In the model (IV), the coefficients were significant for the Democratic Governors ($\beta = -0.009$, $p < 0.01$) and Democratic Senate ($\beta = 0.014$, $p < 0.05$) in the state-level analysis and all political agents were significant in the federal-level analysis (Democratic presidency: $\beta = 0.017$, $p < 0.001$; Democratic senate: $\beta = -0.025$, $p < 0.001$; Democratic House of representatives: $\beta = -0.023$, $p < 0.001$).

5.1. Bootstrapped Tobit regressions tenure-interacted effects

A) State-level analysis

Both Democratic Senate and Democratic Governors' administrations had significant and positive coefficients in the models (I), (II), and (III) (Democratic Governors' models (I) and (III): $\beta = 0.002$, $p < 0.05$; Democratic Governors' model (II): $\beta = 0.002$, $p < 0.01$; Democratic Senate's models (I) and (III): $\beta = 0.002$, $p < 0.05$; Democratic Senate's model (III): $\beta = 0.001$, $p < 0.10$).

Table 2
Bootstrapped Tobit regressions main effects.

Efficiency scores											
Level of analysis	State				Federation				Both		
Models	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)
Independent variables	β	β	β	β	β	β	β	β	β	β	β
(Intercept)	−5017***	−5246***	−5044***	24,529***	1.217	1.095	1.193	20,073***	1.198	1.071	1.172
Contextual variables											
Year	0,003***	0,003***	0,003***	−0,012***	0,000	0,000	0,000	−0,01***	0,000	0,000	0,000
Real personal income	0,057***	0,055***	0,057***	0,059***	0,064***	0,062***	0,063***	0,064***	0,063***	0,061***	0,062***
GINI coefficient	0.056	0.058	0.056	−0.047	0,163*	0,166*	0,163*	0.035	0,166*	0,167*	0,166*
Parties dummies											
Democrat Governor	−0.003	−0.003	−0.004	−0,013***	–	–	–	–	−0.003	−0.002	−0.003
Non-Democratic nor Republican Governor	0,010	0.011	0,010	−0.004	–	–	–	–	0.002	0.003	0.002
Democrat Senate majority (state level)	0.006	0.006	0.006	0.002	–	–	–	–	0.006	0.006	0.006
Democrat congressperson majority	−0.006	−0.005	−0.006	0,000	–	–	–	–	−0.005	−0.004	−0.005
Democrat President	–	–	–	–	−0.001	−0.001	−0.001	0,036***	−0.001	−0.001	−0.001
Democrat Senate (federation level)	–	–	–	–	0,035***	0,036***	0,035***	−0,031***	0,035***	0,035***	0,035***
Democrat House of Representatives (federation level)	–	–	–	–	−0.002	−0.001	−0.001	−0,012***	−0.001	−0.001	−0.001
Tenure controls											
Governors	–	–	–	–	–	–	–	–	–	–	–
Senator's majority (state level)	–	–	–	–	–	–	–	–	–	–	–
Congressperson's majority (state level)	–	–	–	–	–	–	–	–	–	–	–
President	–	–	–	–	–	–	–	–	–	–	–
Senate (federation level)	–	–	–	–	–	–	–	–	–	–	–
House of Representatives (federation level)	–	–	–	–	–	–	–	–	–	–	–
Interactions with respective tenure											
Democratic Governor	–	–	–	–	–	–	–	–	–	–	–
Non-Democratic nor Republican Governors	–	–	–	–	–	–	–	–	–	–	–
Democrat Senate (state level)	–	–	–	–	–	–	–	–	–	–	–
Democrat House of Representatives (state level)	–	–	–	–	–	–	–	–	–	–	–
Democratic President	–	–	–	–	–	–	–	–	–	–	–
Democrat Senate (federation level)	–	–	–	–	–	–	–	–	–	–	–
Democrat House of Representatives (federation level)	–	–	–	–	–	–	–	–	–	–	–
Controls											
Trifectas	0.003	0.003	0.003	0,007ˆ	–	–	–	–	0.001	0.002	0.001
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Coefficient values are standardized.
Model (1) - Inputs: Energy Consumption (BTU) + State's expenditure (dollars) + CO_2 (metric ton), Output: Real GDP; Model (2) - Inputs: Energy Consumption (BTU) + CO_2 (metric ton), Output: Real GDP; Model (3) - Inputs: Energy Consumption (BTU) + Total State's cost (Expenditures + Carbon social cost converted in dollars), Output: Real GDP; Model (4) - Input: State's expenditure (dollars), Output: Real GDP.
***p < 0.001.
**p < 0.01.
*p < 0,05.
ˆp < 0,1.

B) Federal-level analysis

In the models (I), (II), and (III), the Democratic House of Representatives has significantly positive coefficients ($\beta = 0.020$, $p < 0.01$) and democratic presidents have marginally a significantly positive effect ($\beta = 0.006$, $p < 0.10$). Conversely, in the model (IV), Democratic Presidents have a significantly negative effect ($\beta = -0.018$, $p < 0.001$), and Democratic Senate has a significant and positive coefficient ($\beta = 0.028$, $p < 0.001$).

C) Joint state- and federal-level analysis

The complete regression analysis has similar results compared to the individual analysis. The state-level results had shown significant and positive coefficients for Democratic Governors ($\beta = 0.002$, $p < 0.05$) and Democratic Senate ($\beta = 0.002$, $p < 0.05$) in the models (I), (II), and (III), and, alternatively, significantly negative coefficients for Democratic Senate in the model (IV) ($\beta = -0.002$, $p < 0.05$). The federal-level results had shown significant and positive effect for Democratic Presidents (Models (I) and (III): $\beta = 0.006$, $p < 0.05$; Model (II): $\beta = 0.006$, $p < 0.10$) and House Representatives (Models (I) and (III): $\beta = 0.019$, $p < 0.05$; Model (II): $\beta = 0.018$, $p < 0.05$) in the models (I), (II), and (III). In the model (IV), Democratic Presidents had a significant and negative effect ($\beta = -0.018$, $p < 0.001$), Democratic Senate had a significant and positive coefficient ($\beta = 0.027$, $p < 0.001$).

6. Discussion

The first aspect to note is that the results are not sensitive to the political sphere models. In both types of analysis, individual and joint analyses, the results hold as expected, indicating that both political spheres' effects are independent and complementary rather than part of

Efficiency scores												
Both	State				Federation				Both			
(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
β	β	β	β	β	β	β	β	β	β	β	β	β
20,012***	−5237***	−5434***	−5260***	25,692***	0,330***	0,310***	0,329***	0,868***	0,324***	0,308***	0,323***	0,831***
Contextual variables												
−0,01***	0,003***	0,003***	0,003***	−0,012***	–	–	–	–	–	–	–	–
0,066***	0,059***	0,056***	0,058***	0,059***	0,065***	0,063***	0,064***	0,068***	0,064***	0,062***	0,064***	0,068***
0.045	0.072	0,070	0.072	−0.006	0,219**	0,221**	0,220**	−0.103	0,236**	0,230**	0.236	−0.054
Parties dummies												
−0,01**	−0,014**	−0,014**	−0,014**	−0,012*	–	–	–	–	−0,011*	−0,011*	−0,011*	−0.005
−0.016	0.025	0.025	0.025	0.007	–	–	–	–	0.018	0.019	0.018	0.004
0.007	0.001	0.002	0.001	0,010	–	–	–	–	0.001	0.002	0.002	0,016*
0.006	−0,014ˆ	−0,015ˆ	−0,015ˆ	0.002	–	–	–	–	−0.012	−0.013	−0.013	0.007
0,036***	–	–	–	–	−0,035**	−0,034**	−0,035**	0,067***	−0,036**	−0,034**	−0,036**	0,065***
−0,031***	–	–	–	–	0,037**	0,038**	0,037**	−0,233***	0,039**	0,039**	0,039**	−0,236***
−0,013***	–	–	–	–	−0,046*	−0,045*	−0,046*	0.003	−0,042*	−0,041*	−0,042*	−0.002
Tenure controls												
–	0,000	0,000	0,000	0.001	–	–	–	–	0,000	0,000	0,000	0,001ˆ
–	−0,002**	−0,002**	−0,002**	0,002**	–	–	–	–	−0,002**	−0,002**	−0,002**	0,002***
–	0,000	0,000	0,000	0,000	–	–	–	–	0,000	0,000	0,000	0,000
–	–	–	–	–	−0.001	−0.001	−0.001	0,013***	−0.001	−0.001	−0.001	0,012***
–	–	–	–	–	0.002	0.002	0.002	−0,019***	0.003	0.003	0.003	−0,02***
–	–	–	–	–	−0,005**	−0,005**	−0,005**	0.001	−0,005**	−0,005**	−0,005**	0.001
Interactions with respective tenure												
–	0,002*	0,002*	0,002*	0.001	–	–	–	–	0,002*	0,002*	0,002*	0,000
–	−0.006	−0.006	−0.006	−0.003	–	–	–	–	−0.007	−0.007	−0.007	−0.005
–	0,002*	0,001ˆ	0,002*	−0,002*	–	–	–	–	0,002*	0,002*	0,002*	−0,002*
–	0.001	0.001	0.001	−0.001	–	–	–	–	0,000	0.001	0,000	0,000
–	–	–	–	–	0,005ˆ	0.005	0,005ˆ	−0,019**	0,006ˆ	0,005ˆ	0,006ˆ	−0,018***
–	–	–	–	–	0,000	0,000	0,000	0,028**	0,000	0,000	0,000	0,027***
–	–	–	–	–	0,021**	0,021**	0,021**	−0.007	0,019*	0,019*	0,019*	−0.007
Controls												
0.001	0.002	0.002	0.002	0,007ˆ	–	–	–	–	−0.001	0,000	−0.001	−0.001
Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

the same phenomena. Hence, it is a preliminary and necessary evidence to support our moderation effect prediction formalized in our hypothesis four. From a total of six political agents, four had a significant effect in the expected direction, as reflected in the models (I), (II), (III). Both executive positions - governors and presidents - had the predicted effect supporting our hypothesis one, which envisioned higher eco-based efficiency scores for the democratic party. The model (IV), which is based only on financial inputs and outputs, partially supported our hypothesis two. Democratic Presidents were less efficient than the ones of Republicans, suggesting a tradeoff when applying the green policies instead of a strict economic agenda. However, the tradeoff effect fades for governors, showing the similar performance between Democrats and Republicans.

The results from senators and house representatives require an in-depth analysis since they are the same in both the state and federal spheres; thus, increasing the complexity to understand their behaviors. First, shall us discuss the senate's results, and then we proceed to the results of the house of representatives? On the one hand, at the state level, Democratic Senators, as predicted in the hypotheses 1 and 2, had a significantly positive effect in the models (I), (II), and (III) and a significantly negative effect in the model (IV). On the other hand, at the federal-level analysis, Democratic Senators were the same as the ones of Republicans in the models (I), (II), and (III) and were more efficient in the model (IV). Since senators hold more power in their respective states, given the small number of seats, we expect a high political identification of senators to the state they represent, compared to the nation. Therefore, we suggest that senators focus on their region to address their electorate's expectations while implementing their political party policies. In contrast, their administration towards the nation is based on economic growth since it provides more political stability and is less representative of their administrative role, contrasting with the state level.

Democratic House Representatives had analogous but mirrored results juxtaposed against the senators: In the models (I), (II), and (III), Democratic House Representatives' efficiency scores were not different from the ones of Republicans in the state level ($\beta = 0.001$, n.s), but were significantly positive (Models (I) and (III): $\beta = 0.019$, $p < 0.05$; Model (II): $\beta = 0.018$, $p < 0.05$) in the federal level. In the model (IV), Democratic House of Representatives was the same as the one of Republicans in both the state ($\beta = 0.000$, n.s.) and the federal levels ($\beta = -0.004$, n. s.). Diverging from the senators' context, the House of Representatives has significantly more seats in each state, diluting their power across their peers in their state. We assume that the House Representatives have less political identification with their state; henceforth, focusing their party agenda implementation on the national scope.

The findings regarding Senators and House Representatives'

discrepancy in the state and federal levels reinforce the evidence supporting our hypothesis four, which predicts a political distancing moderation effect attenuating the correlation between the democratic party and green efficiency scores. Although we did not directly measure the coefficients and significance levels of the context over the senator and house representatives' behaviors, there is an evident impact of the political sphere on the eco-efficiency scores, indicating distinct behaviors towards different contexts.

6.1. Tenure

There was a significant and negative effect of the senate political party tenure on the efficiency scores ($\beta = -0.001$, $p < 0.05$) in the models (I), (II), and (III). However, the coefficients of the other political agents were not significant; thus, it is not enough to reject the null hypothesis, suggesting a political party-conditioned tenure effect.

6.2. Robustness checks

The DEA method, by design, has substantial internal validity, which could compromise the generalization claims, although the myriad of authors have defended its statistical robustness. Given that we covered our proposed data in the period of study and provided additional techniques to remove the bias from our analysis including bootstrap, the use of Tobit regressions, and the adoption of several different models, these precautions should provide solid results to compare the efficiency scores. However, a major caveat is the possibility of influence from external shocks, which could confound our results. Therefore, we included a dummy for the subprime financial crisis years (2007 and 2008) as a robustness check. In our models, the output was always the GDP; and, if our models were sensitive to the exogenous shocks, we would expect a crisis dummy effect on the efficiency scores. The crisis dummy was not significant in the models (I), (II), and (III) and was significant in the model (IV). In all the models, the political agents maintained their significance level and the same sign. Accordingly, we assume that an eventual and specific exogenous shock is not enough to alter our conclusion.

6.3. Contextual variables

We propose to perform an exploratory analysis on time, measured by year, as a contextual factor that affects energy efficiency for two main reasons (1) with time, the environmental concerns all over the world have increased, which prompted the U.S. to adopt relevant measures in favor of this cause, this might encompass the energy efficiency-focused measures; (2) time passage brings new technological features that could enhance a country's energy efficiency. Regarding our first point, over time, the U.S government has allocated significant resources (Adua et al., 2021) and created several enterprises to promote energy conservation and energy efficiency in the country such as the National Energy Act in 1978, the Clean Air Act Amendments in 1990 and the Energy Policy Act of 2005 (Dixon et al., 2010). Therefore, the country has fulfilled the improvements in energy efficiency within several sectors of the economy, including transportation, industry, and electric power (Dixon et al., 2010).

In addition, as the time passes, besides the emergence of new regulatory initiatives, programs, and policies aiming at expanding energy efficiency (Dixon et al., 2010), the technological advancement might also contribute to the achievement of this goal. Particularly, Mukherjee (2010) highlights that as technology progresses, it is possible to transcend the best practice frontier to generate a high increase in the outputs produced using a smaller amount of energy inputs. Similarly, the ecological modernization advocates posit that the efficiency advances provided by technology will reduce the society's impact on natural resources and reduce energy consumption (Adua et al., 2021).

Moreover, with regards to the reduction of carbon emissions, which is a desirable outcome of energy efficiency processes, Richels and Blanford (2008) uphold that technology plays an important role in controlling greenhouse gas emissions, for example, the development of carbon capture and storage (CCS) technologies and new nuclear plants are likely to diminish the dependence on natural gas and reduce the costs involved in the process of decarbonization. Furthermore, it is expected that the technological developments will allow an increase and, eventually, the full transition from fossil fuels to cleaner and environment-friendly energy sources, suggesting once more that the association between emissions, energy use, and other factors is dynamic over time (Soytas et al., 2007).

According to the literature, the year is one of the most important drivers of efficiency score due to the technological advancement. However, in some analyses, we had to remove the "year" variable since we had collinearity issues between federal-level tenure and year; thus, we limit our contextual variable analysis to the state-level political sphere. As expected, the year was significantly positive in the models (I), (II), and (III). On the other hand, the efficiency scores, in the economic efficiency model, degrades over the years. This is possibly attributed to the increase in the state expenditure with social and environmental policies.

An improvement in energy efficiency entails higher energy accessibility for lower-income individuals (Langlois-Bertrand et al., 2015), which would promote a reduction in the Gini index. However, the Gini index, in our results, was positively related to the efficiency scores. A tentative explanation for this phenomenon is that, with higher inequality, fewer people have access to goods and services, this will reduce energy consumption and CO_2 emissions. Hence, this will increase the efficiency scores.

6.4. Controls

Every US state has a distinct infrastructure, citizen customs and culture, and energy matrix, decisively impacting their efficiency scores. For instance, coastal states, compared to the countryside states, have access to port facilities and naval transportation modal, which leads to an alternative way to transport and exchange goods with their specific profit margin and CO_2 emission rate per volume. Thus, in our analysis, we controlled the political party's efficiency scores by the US state's fixed effect, removing the potential bias from the regional characteristics over the efficiency scores estimates.

Despite the scarce literature on unified political party control, known as "trifecta," there is evidence of the managerial impact of this phenomenon. For instance, Pomeranz et al. (2017) identified that the democratic trifectas enacted more laws related to public health when compared to the Republican-controlled administrations. Alternatively, the Republican trifectas enacted more physical activity-related laws than other political configurations. Hence, we controlled the efficiency scores by adding two trifectas' dummies to remove the potential governability-discrepancy bias, one at the state-level political sphere and the other at the federal-level. The results have shown that both political spheres did not have a significant effect in our eco-efficiency models. Conversely, the result evidenced a significant and negative effect only on the federal-level sphere trifecta over our economic efficiency model (IV) ($\beta = -0.188$, $p < 0.001$).

7. Conclusion

In this study, we have accessed the impact of political party on energy efficiency, the role of tenure in the gubernatorial administrations, and the moderation effect of political distancing in terms of political spheres through a two-stage DEA-Tobit bootstrapped regression analysis. The Democrats consistently demonstrated higher energy efficiency scores, while some Republican actors obtained higher scores in our financial model. Further, the political tenure as a feature had mild or mixed results in both model types, evidencing that tenure as an isolated

attribute is not enough to produce a specific effect as the political entrenchment. However, tenure plays a crucial role when interacting with the political administration in the analyses, suggesting a contextual-conditioned effect. Lastly, there is an indication of behavioral response to the political contexts. While the two executive agents were consistent in their political sphere, both legislative chambers had mirrored efficiency responses according to the political spheres, suggesting that senators implement policies at the state level and the house representatives focus their agenda on the federal level.

Moreover, we have presented the contextual effects of the time passage and Gini index in our models, providing more insights for further studies. In the period of analysis, we confirmed the positive time-passage effect on energy efficiency, indicating that: (i) technology may reduce the environmental harm in the future; (ii) there is a growing concern on policy implementation towards climate change mitigation; or (iii) both mechanisms are working in parallel. On the other hand, the Gini index results suggest that elevated access to energy and resources from the lower social classes may increase the CO_2 emission through energy use; therefore, it is necessary to foster more innovative solutions to deal with both inequality and climate change at the same time, without compromising one or the other.

Our main contribution is to highlight how relevant is the role of our authorities while conducting bureaucratic affairs. The climate change concerns increase the pressure over the global leaders and in the society. Hence, the empirical findings towards political actors' managerial efficiency are a befitting resource to monitor and hold administrations accountable. It is a form to increase the electorate's awareness of the incumbent leader's performance and capacity to deal with the challenges of the new millennia. Additionally, it grants a clear perspective regarding the direction to which each political player is navigating to and the fruits the society will reap built on the chosen political seeds planted today. The political agendas, indeed, have an impact on the future outcomes, and each political party is more efficient in its advocated goal and vision. Also, the empirical findings are in line with the Democrats and Republicans' ideologies and their campaigns. Thus, it is up to voters to decide which track they consider more urgent: unrestricted economic growth at a faster pace or sustainable and more efficient economic growth.

7.1. Limitations

The main concern with our adopted method is to generalize our results to different contexts. Although we reduced the uncertainty concerns with exogenous economic shocks such as the subprime financial crisis, several contextual conditions of the present North American political structure may enhance or attenuate political parties' influence on the efficiency scores. The U.S. has strong institutions and two well-defined political parties, which balance and limit the high administration power, providing continuity to ongoing projects and governance stability. For instance, Brazil has several political parties, which reduces the loyalty to the political party agenda, and the energy efficiency may be more related to the government actors' aspirations than to the political party, except for some extremist ideology parties.

Further caution and additional studies are necessary to reach solid conclusions. For instance, our last hypothesis has preliminary evidence support. More research data is required to address and confirm the political identification to the state level and federation spheres. Despite the effort to clear the potential confounding, the DEA-Tobit design has limited reach to provide the causality claims. Hence, given the existing literature and the data, there is no better explanation for the observed correlations, which could be insensitive to a comprehensive list of distinctive models adopted, including the potential spurious correlations. We recommend, though, additional qualitative analysis or controlled field experiments to evaluate our moderation hypothesis four. Although the results are in line with our predictions and the current literature, the evidence is a tentative one. It cannot provide robust evidence without further directed research. Nevertheless, all the results were consistent across all models and additional analyses. The contribution of this work surpasses the initial expectations and provides a groundwork to foster the discussions on this relevant topic, which is far from being fully explored.

CRediT authorship contribution statement

Conceptualization, J.A., J.N., L.E., M.A., and P.W.; methodology, J.A., J.N., L.E., M.A., and P.W.; software, J.A. and M.A.; validation, J.A., P.W., A.T.; formal analysis, J.A. and M.A.; investigation, J.A. and M.A.; Resources, P.W.; data curation, M.A.; writing - Original Draft J.N., L.E., and M.A.; writing—review and editing, J.A., P.W., and Y.T.; visualization, J.N., L.E., and M.A.; supervision, P.W. and Y.T.; project administration, P.W.

Conflict of interest

The authors declare no conflict of interest.

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