Impact of Energy-related Uncertainties and Climate Policies on Australia's Energy Transition

Shahzad Alvi, William Connell, Amjad Naveed

Abstract

Understanding the impact of uncertainties on energy transition (ET) is crucial for achieving long term sustainability. This study investigates the impact of climate policy uncertainties and oil market shocks on the ET in Australia, using data from 1990 to 2020. In this study, we used the novel Dynamic Autoregressive Distributed Lag (DARDL) model, and the results indicate that climate policy uncertainties negatively affect the ET in the long term, while oil supply shocks and aggregate demand shocks accelerate ET. In the short term, energy-related uncertainty and aggregate demand shocks drive ET, whereas oil price shocks have a negative effect. From policy perspective, this study suggests the need for consistent climate policy in the case of Australia to achieve a steady ET and meet net zero emissions targets.

Keywords: Oil supply shock; Aggregate demand shock; Oil price shock; Economic uncertainty; Climate vulnerability; Renewable energy

1. Introduction

The intersection of two key challenges looms large in the contemporary energy landscape: the inherent uncertainty induced by oil shocks characterizing the energy market and the concurrent transition to renewable resources as a pivotal strategy to attain zero-emission targets (Hafner & Tagliapietra, 2020). Energy transition refers to the structural shift from fossil fuels to renewable energy sources, driven by economic, environmental, and policy considerations (Fouquet & Pearson, 2012). Understanding ET is crucial as it intersects with macroeconomic stability, investment decisions, and climate policies. Simultaneously, the transition to renewables offers the potential to reduce the long-term uncertainties associated with fossil fuel dependence (Krane & Idel, 2021; Pfenninger et al., 2014).

The impact of oil market uncertainty on the global economy has been a significant concern since the 1970s, prompting extensive research into the macroeconomic repercussions of fluctuations in oil prices. The oil market exhibits significant price uncertainty, which can be attributed to various factors, including geopolitical conflicts, disruptions in supply, and changes in global demand (Kilian, 2009). The fluctuation in prices can substantially affect energy costs for consumers and businesses, thereby posing difficulties in effectively strategizing and allocating funds for energy expenditures (Byrnes, 2013).

Though a voluminous body of literature has evolved investigating the impact of oil prices for macroeconomic performance and policies (see, for example, (Barsky & Kilian, 2002; Hamilton et al., 2008; Kilian, 2008), examining the adaptation strategies of various economies to oil market dynamics is a relatively less ventured area of oil research. The transition from nonrenewable to renewable energy can be regarded as an adaptation strategy driven by oil market dynamics. The presence of uncertainty in oil markets is a crucial factor to consider when examining the necessity of an ET (Esmaeili et al., 2024). Oil market dynamics are multifaceted and may induce varying responses with respect to the energy policies of the countries. For instance, higher levels of oil prices may induce oil-exporting countries to invest more in the traditional energy sector, hampering energy diversification (Dubash & Florini, 2011; Karanfil & Omgba, 2023). On the other hand, oil prices may play a crucial role in shaping the ET, with higher prices stimulating exploration and investment in alternative energy sources (Fouquet, 2016).

Since the theoretical works of Friedman (1968) and Bernanke (1983), economic analysis has focused a significant amount of attention on the study of uncertainty in the state of the economy. Recent research provides evidence that uncertainty in macroeconomic aggregate variables has a negative impact on economic growth and investment (Brogaard & Detzel, 2015; Julio & Yook, 2012) and (Handley & Limao, 2015). However, some studies concentrate on the economic effects of uncertainty in the energy market. According to the research conducted by (M. Balcilar et al., 2019; Bernanke, 1983; Pindyck, 1993, 1999), one of the effects of uncertainty relates to fluctuations in energy prices, which can lead to uncertainty regarding the path of energy prices in the future.

Literature on the ET has recently emerged, and existing studies can be divided into three strands. One which discusses the impact of uncertainty induced by oil price shocks and its impact on ET (M. Balcilar et al., 2019; Murshed et al., 2021); The second strand of literature examines the role of environmental, fiscal, and monetary policies on ET (Campiglio, 2016; Chen et al., 2019; Hu et al., 2022; Tol, 2023; Wang et al., 2023) and the third strand of literature discourses the role of financial and technological development on the ET process (Alariqi et al., 2023; Bai & Lin, 2023; Irfan et al., 2023; Yang et al., 2024). However, one might consider that the system is absorbing the uncertainty induced by oil shocks due to the strength of the financial system, especially in developed countries. This would allow countries to shift towards other immediately available non-renewable energy resources, such as coal and gas, and even enable them to purchase oil at higher prices, which would disentangle the effect on the ET. On the other hand, it can appear that strict environmental policies and concerns may make it difficult for countries to switch to other resources, preventing the effect of ET from being disentangled.

Building on the three strands of opinion discussed, this study has three specific objectives: first, to examine the short-term and long-term effects of energy market dynamics and climate policy uncertainties on the ET in Australia, highlighting the role of regulatory stability in shaping renewable energy adoption. Australia's heavy reliance on fossil fuels and exposure to energy-related vulnerabilities make it a compelling case for exploring how uncertainties and shocks influence ET. Second, to analyze the impact of oil supply shocks and price fluctuations on the pace and direction of ET, considering Australia's dependence on global oil markets. Third, to assess the

impact of aggregate demand shocks on ET and how this varies between the short and long term.

Based on these objectives, the current study will answer:

> (1) How do energy market dynamics and climate policy uncertainties affect Australia's ET process in the short and long term, and what role does regulatory stability play in shaping renewable energy adoption?
>
> (2) What is the impact of oil supply shocks and price fluctuations on Australia's ET, considering its dependence on global oil markets?
>
> (3) How do aggregate demand shocks influence Australia's ET, and how does their impact differ between the short and long term?

Using data over the period 1990 to 2020 and employing a novel Dynamic Autoregressive Distributed Lag (DARDL) model, the study finds that in the long term, energy-related uncertainty negatively affects ET, while oil supply shocks and aggregate demand shocks facilitate ET. Conversely, climate policy uncertainty becomes significant obstacles in ET progress over time. In the short term, energy-related uncertainty and aggregate demand shocks support ET, whereas oil prices affect negatively. Climate vulnerability, however, has no effect in the short run. From policy perspective, this study suggests that focusing on energy-related uncertainty are important for shaping Australia's ET both in the short and long term compared to climate change considerations.

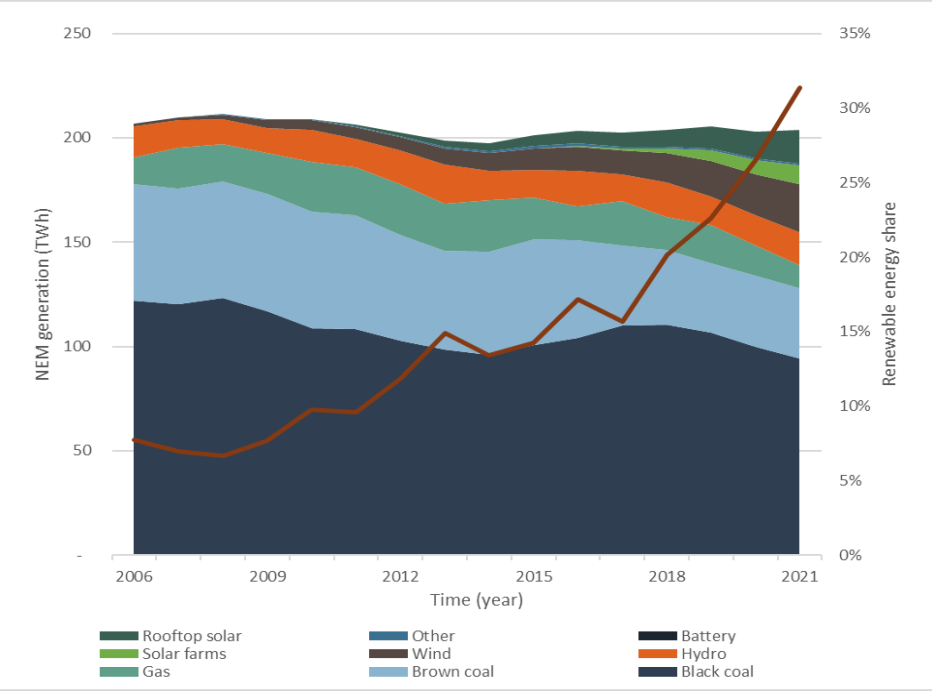
Australian Context

The Australian ET is shaped by its acute climate risks, its renewable energy capacity, and its role as a coal and gas exporter despite being an oil importer. Li et al. (2020) provides a comprehensive analysis of the factors and progress of the Australian ET. They identify multiple renewable electricity sources which Australia has substantial capacity to adopt. For instance, they note Australia has significant potential to adopt wind energy, given its relative and declining cost and the abundant coastal regions (Li et al., 2020). Australia is bombarded by 16 Exawatt hours of solar radiation, which constituting approximately 80,000 times its electricity requirements.

A patchwork of state-level and federal policies has influenced the Australian ET. For instance, the Australian Renewable Energy Target (RET), introduced in 2001, incentivized the uptake of renewables by homeowners and large-scale renewable energy projects (Dodd & Nelson, 2019). The Australian Renewable Energy Agency and Clean Energy Finance Corporation provide funding for renewable energy research and development as well as fund renewable energy projects, respectively (Dodd & Nelson, 2019). The Emissions Reduction Fund and the short-lived Australian carbon price between 2012 and 2014 provides disincentives for greenhouse gas emissions.

Although the Australian ET is underway, see Figure 1, and the immense potential for renewable ET, institutional hinderances have slowed the transition (Dodd & Nelson, 2019). Australian institutional and policymaker ideological resistance (Hudson, 2017) in additional to Australian energy policy uncertainty and fluctuations has been highlighted as a major obstacle. Other obstacles include: (1) a need for a greater diversity of renewable energy production to reduce regional energy supply risk; (2) distance between renewable energy production and energy marketplaces; (3) consistent government incentives are required to promote uptake of small-scale renewable energy (Li et al., 2020).

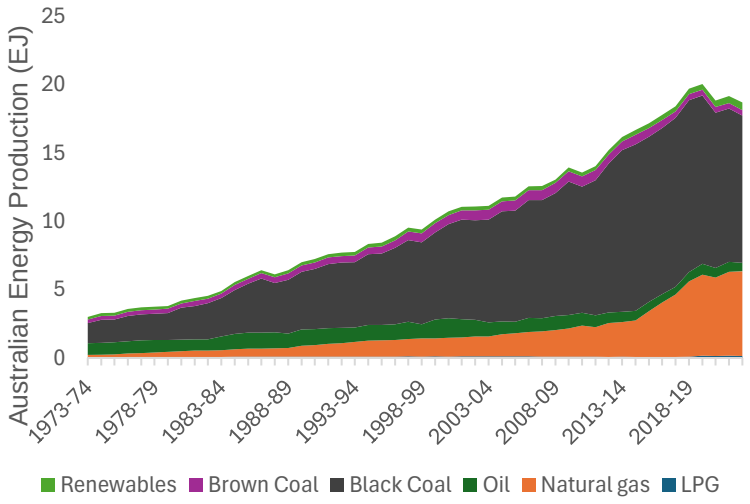
Figure 1: Australian electricity production by source

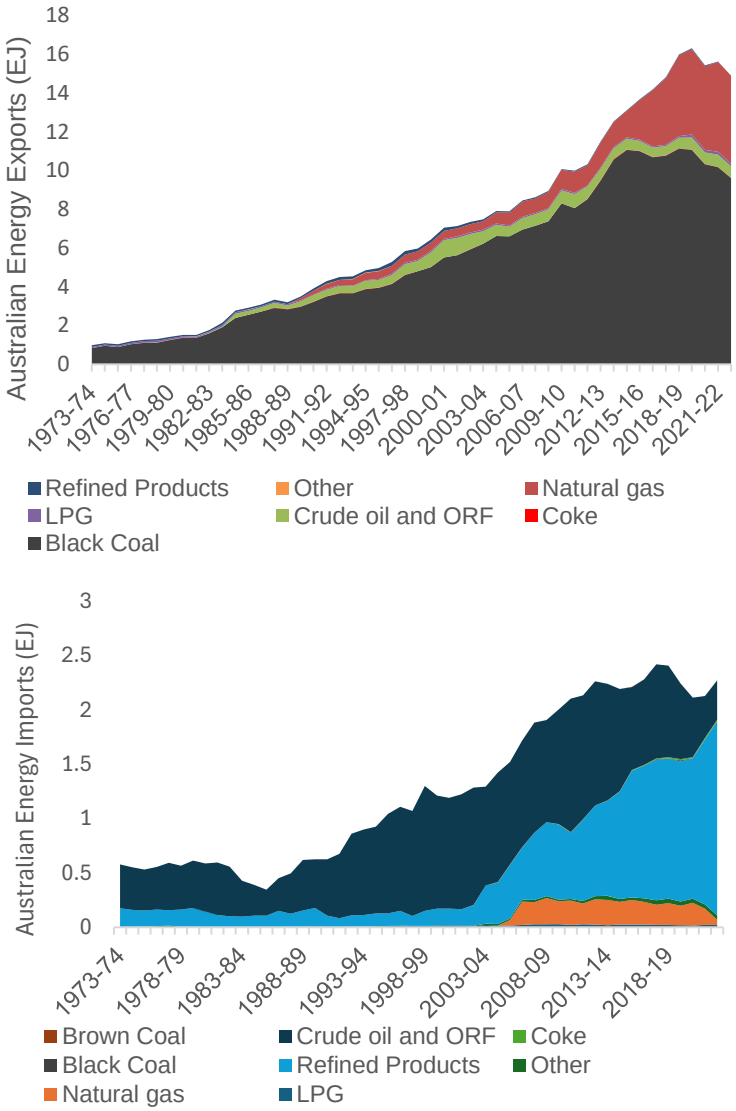


Source: Australian Energy Regulator

A shown in Figure 2, Australia's energy exports have undergone significant transformation, particularly in the fossil fuel sector. Black coal exports surged from 836.9 PJ in 1973–74 to 9,606 PJ by 2022–23, driven by global demand for thermal and metallurgical coal. Natural gas exports, negligible until the late 1980s, exploded after the 2000s with LNG projects, reaching 4,540 PJ in 2022–23. Crude oil and ORF exports fluctuated, peaking in the 1990s (e.g., 547 PJ in 1999–00) before declining due to domestic refining reductions. Meanwhile, LPG exports grew steadily, hitting 149 PJ in 2021–22. Renewable energy production, though still a smaller share, rose from 197.5 PJ in 1973–74 to 553.6 PJ in 2022–23, reflecting gradual shifts toward sustainability. Domestic production of natural gas and coal dominated, with natural gas output climbing from 172 PJ in 1973–74 to 6,200 PJ in 2022–23.

Figure 2: Australian Energy by Source





Source: Australian Government Department of Climate Change, Energy, the Environment and Water (2024)

Australian energy imports reveal reliance on foreign refined petroleum products and crude oil, despite its status as a major fossil fuel exporter. While Australia produces crude oil, domestic crude oil and NGL production declined from 858 PJ in 1973–74 to 626 PJ by 2022–23 (DCCEEW, 2024). This decline forced increased reliance on crude oil imports, which peaked in the late 1990s (1,150 PJ in 1998–99) and remained significant (362 PJ in 2022–23) to meet domestic refining and consumption needs. Automotive diesel (ADO) imports skyrocketed from 49.4 PJ in 2001–02 to 1,150 PJ in 2022–23, while automotive gasoline imports surged from 40.7 PJ in 2000–01 to 345 PJ by 2022–23. This dependence leaves Australia vulnerable to global price shocks and supply disruptions, despite its vast LNG and coal exports. Bitumen imports, tied

to infrastructure demands, grew to 41 PJ in 2022–23, highlighting gaps in domestic downstream processing. The position of being a top energy exporter, yet reliant on imported refined products, underscores structural weaknesses in Australia's energy security and has consequences for the Australian ET.

The remainder of this paper is followed by Section 2, which focuses on the related literature. Section 3 discusses the methods. Section 4 presents the results and discussion. Finally, Section 5 presents the conclusion.

Literature Review

Here, we summarise literature related to the impact of energy related uncertainty, oil market shocks, aggregate demand, climate vulnerability, and policy uncertainty on the ET process.

Balcilar et al. (2019) examines the impact of energy market uncertainty shocks on the ET process. The authors use a panel VAR model to identify energy market uncertainty shocks and employ five equation time-varying parameter data stochastic volatility model to a sample of 28 European Union (EU) economies between 1990 to 2015. The authors identify that oil price and energy price uncertainties are factors contributing to the renewable ET. Likewise, Igeland et al. (2024) explore the impact of economic policy uncertainties on the risk and financial returns of renewable energy companies. Using fixed effects regression, they find economic policy uncertainty positively impacts the returns of renewable energy shares, suggesting a positive impact on the renewable ET. Employing a similar method, Işık et al. (2024) examines the global energy uncertainty between the years 1996 to 2021, which they attribute to global energy market dependence. They suggest renewable energy uptake reduces this uncertainty and fossil fuel price variations. Udeagha and Muchapondwa (2022) examine how policy uncertainty moderates the South African Environmental Kuznets Curve (EKC) between 1960 and 2020. They use the dynamic ARDL simulation approach, which suggests that uncertainty reduces renewable energy consumption and higher emissions. Ivanovski and Marinucci (2021) examine the impact energy policy uncertainty on renewable energy consumption using various panel data methods. Using a sample of 23 developed and developing economies of annual observations between 1997 to 2015, they find energy policy uncertainty significantly reduces renewable energy consumption. Similar findings have been found elsewhere

(see, for example, Barradale (2010)). Related extant literature explores the mediating role of policy frameworks. Campiglio et al. (2018) provides an analysis of how central banks could redirect capital to renewables via green monetary policies. They argue green bonds and carbon risk disclosures reduce investor uncertainty. Murshed et al. (2021) used FMOLS among other panel regression models to a sample of South Asia countries between 1990 and 2018 to examine the impact of environmental regulation on ecological footprint in the context of the EKC. Their results suggest environmental regulations and renewable energy use reduce the ecological footprint.

The relationship between aggregate demand and renewable ET has garnered attention for several decades. A prominent framework to analyse the impact of aggregate demand on the renewable ET is the EKC framework. For instance, Mahmood et al. (2023) provides a summary of multiple papers that examine the EKC in China. The highlight that as the standard of living increases beyond a threshold in China, renewable energy consumption becomes a prominent mechanism for reducing emissions intensity. Business cycle fluctuations also drive renewable energy investment and consumption dynamics. For example, Yasmeen et al. (2022) explores how phases of the business cycle drive renewable energy investment for a sample of OECD countries between 1996 and 2015. They identify economic expansions that contribute to renewable energy investment using fixed effects regression.

The relationship between oil market volatility and renewable energy adoption has been studied using a wide variety of methodologies. For instance, Murshed and Tanha (2021) explores the non-linear relationship between oil price shocks and renewable energy adoption in South Asian countries. Their results suggest oil import dependency should be phased out and the renewable ET should be promoted via renewable energy imports. Nchofoung (2024) examines the impact of oil price shocks on the renewable ET for a sample of 53 African countries between 2000 and 2020. The author employs a panel VAR and identify the shocks hinder the African renewable ET. Evans (2024) explores the impact of oil prices on the renewable ET of a sample of size African countries between 1995 to 2020. They use a nonlinear ARDL model and find increasing oil prices contribute to increased renewable energy investments. Mukhtarov et al. (2020) examines the relationship between oil prices and economic growth for Azerbaijan between 1992 and 2015. Using an ARDL specification, their results suggest high oil prices delay the renewable ET, likely because Azerbaijan is a

net oil exporter. These studies suggest when prices rise, countries that predominately import oil substitute for domestic- or imported renewable energy consumption. Oil exporters are encouraged to increase production to profit from higher prices, as seen in the context of Azerbaijan. Australia is an exporter of coal and natural gas, but imports its oil supply, suggesting higher prices should incentivize renewable energy consumption.

Climate vulnerability adds urgency to these transitions, and a large literature explores the positive impact renewable energy has on climate vulnerability. However, inherent domestic climate vulnerabilities in principle should incentives the renewable ET because of climate change damage. Hao and Shao (2021) examine a panel dataset of 118 countries between 1995 and 2015 and use cross-sectional Prais-Winsten regression. They identify climate vulnerabilities to promote the renewable ET. Kim and Park (2023) examines regional heterogeneity between climate vulnerabilities and renewable energy uptake across 121 countries between 1992 and 2019. Using a fuzzy analytic hierarchy process the authors suggest that while renewable energy consumption increases with climate vulnerability, it is dependent on adaptive capacity, bypassing countries with low capacity.

This study advances the discourse on the ET process by addressing critical gaps in the existing literature. While prior research has predominantly examined oil market shocks, policy uncertainty, macroeconomic activity, and climate vulnerability in isolation or within generalized global frameworks, this paper synthesizes these factors within Australia's unique context—a fossil fuel-dependent, climate-vulnerable economy with fragmented governance. We use a novel Dynamic Autoregressive Distributed Lag (ARDL) simulation model to disentangles the short- and long-term effects of energy-related uncertainty, oil supply/demand shocks, aggregate demand, and climate policy dynamics on ET, a methodological advancement over static panel approaches used in earlier works (e.g., Murshed et al., 2021; Wang et al., 2023).

Research Method

As discussed earlier, the study's objectives pertain to measuring the responsiveness of ET towards the uncertainty, energy market and climate dynamics in Australia. Accordingly, the general form of the study's model is given in Equation 1:

$$eti_t = f(eui_t, op_t, os_t, ad_t, cvi_t, cpu_t) \qquad (1)$$

Where eui represents the comprehensive ET index, eui is energy-related uncertainty, op is oil-specific demand measured by real oil prices, os is oil supply, and ad is oil demand measured by world economic activity, cvi is climate vulnerability index, and cpu is climate policy uncertainty.

However, following (Kilian, 2009) our empirical approach considers all three types of oil market shocks: oil price shock, oil supply shock, and aggregate demand shock as the major indicators of energy market dynamics. Along with this, energy-related uncertainty is also considered an important indicator of energy market dynamics. Therefore,

$$EMD = [eui, op, os, ad] \qquad (2)$$

EMD represents energy market dynamics.

Whereas climate vulnerability index and climate policy uncertainty are considered important indicators to measure climate dynamics. Therefore,

$$CD = [cvi, cpu] \qquad (3)$$

CD represents climate dynamics.

Consequently, the empirical form of the model given in Equation 1 takes the following form:

$$eti_t = \alpha_0 + \alpha_1 eui_t + \alpha_2 op_t + \alpha_3 os_t + \alpha_4 ad_t + \alpha_5 cvi_t + \alpha_6 cpu_t + \gamma_t \qquad (4)$$

All the variables included in the model are pertinent to examine the responsiveness of ET towards energy-market dynamics and climate dynamics, such that, oil prices play a significant role in shaping the ET process through various channels. The volatility of oil prices can have both positive and negative effects on investment decisions and the competitiveness of renewable energy sources. For instance, when oil prices are low, non-renewable energy sources may become more economically appealing and cost-effective, impeding the adoption of renewable energy. Conversely, high oil prices can incentivize investments in renewable energy compared to conventional energy sources. However, during periods of low oil prices, there may be decreased investment in renewable energy projects due to the perceived cost competitiveness of traditional energy sources (Murshed et al., 2021).

Similarly, oil supply disruptions can impact the ET process in both positive and negative ways. These disruptions can lead to fluctuations in oil prices, wherein an increase in oil supply has the potential to lower prices, thus potentially impeding investments in renewable energy sources (Boer et al., 2023). Nonetheless, abrupt oil supply shocks resulting from geopolitical tensions or natural disasters may prompt policy responses aimed at enhancing energy security by reducing reliance on oil imports and encouraging advancements in the ET. The effects of such shocks are also contingent upon factors such as sustained policy efforts and technological advancements (Özkan et al., 2024).

Moreover, effectively managing aggregate demand, fostering energy efficiency, and expediting the uptake of renewable energy technologies are pivotal strategies in realizing a sustainable ET and mitigating worldwide environmental issues. Therefore, this study intends to examine the impact of aggregate demand on the ET process. Changes in the aggregate demand can positively influence the ET process. Heightened aggregate demand can stimulate investments and advancement in renewable energy technologies. Additionally, higher aggregate demand spurs greater oil demand, leading to increased prices, thereby potentially expediting the shift toward sustainable energy sources. However, aggregate demand can also hinder the ET through the lock-in effect, as highlighted by (Pieroni, 2023)

According to (M. Balcilar et al., 2019), different types of uncertainties have strong time-varying effects on the ET process. Both climate policy uncertainty and energy-related uncertainty exert a negative impact on the ET process. Energy related uncertainty referring to varying energy policies, market dynamics, and technological advancements can hinder investments in renewable energy projects and infrastructure. Additionally, geopolitical tensions, conflicts, or trade disputes can also destabilize the global energy markets, impacting the accessibility and cost of energy resources and impeding the ET process. Similarly, increased uncertainty in climate policies can influence firms' investment decisions, potentially leading to delays or insufficient investment in renewable energy projects. This is often exacerbated by firms' susceptibility to financing constraints, which can magnify their response to fluctuations in climate policies. Contrary to this, fluctuations in climate policy could prompt a shift in the energy structure, resulting in greater adoption of renewable energy sources (for example, as discussed by (Liang et al., 2022) and (Wakiyama &

Zusman, 2021) also propose that the enactment of climate-oriented policies leads to significant advancements in renewable energy utilization and reductions in greenhouse gas emissions. Moreover, climate vulnerability also impedes the ET process by exacerbating energy security risks and affecting technological advancement.

Data and Variables

The data spans from 1990 to 2020, with detailed information presented in Table 1. Additionally, Table 2 provides the descriptive statistics for the variables analyzed in this study.

Table 1: Data and Variable Transformation

Variable Name	Variable Description	Data Source
Eti	Comprehensive Energy Transition Index	Hu et al., 2022
Eui	Energy-related Uncertainty Index	Dang, et al., (2023)
Op	Oil price	International Energy Agency Review, March 2022, and Kilian (2019) index
Os	Oil Supply	
Ad	Aggregate economic activity	
Cvi	Climate Vulnerability Index	Wen at al., (2020)
Cpu	Climate Policy Uncertainty	Gavriilidis, K. (2021)

Source: Authors own tabulation

Table 2: Descriptive Statistics

Variable Name	Mean	SD	Min	Max
Eti	0.17	0.10	0.02	0.38
Eui	23.34	5.49	13.36	37.23
Op	313.08	202.00	79.97	702.38
Os	83.12	10.54	66.79	100.5
Ad	1.84	56.16	-90.08	144.024
Cvi	0.32	0.011	0.30	0.33
Cpu	94.41	40.87	34.92	218.63

Source: Authors own tabulation

Empirical Approach

To analyze the measure of the responsiveness of ET towards energy market dynamics and climate dynamics in Australia, this study applies the novel Dynamic Autoregressive Distributed Lag Simulations model (DARDL), on the time series data from the year 1990 to 2020.

The novel dynamic ARDL simulations model developed by (Jordan & Philips, 2018) is highly effective for examining cointegration as well as long-run and short-run equilibrium relationships in both levels and differences. The dynamic ARDL representation of the above model (equation 04) is given as follows:

$$\Delta eti_t = \rho_0 + \rho_1 eti_{t-1} + \rho_2 \Delta eui_t + \rho_3 eui_{t-1} + \rho_4 \Delta op_t + \rho_5 op_{t-1} + \rho_6 \Delta os_t + \rho_7 os_{t-1} + \rho_8 \Delta ad_t + \rho_9 ad_{t-1} + \rho_{10} \Delta cvi_t + \rho_{11} cvi_{t-1} + \rho_{12} \Delta cpu_t + \rho_{13} cpu_{t-1} + \rho_{10} ECT_{t-1} + \Gamma_t \quad (4)$$

2. Results and Discussion

For a novel Dynamic ARDL simulations model, the dependent variable must be stationary at the first difference, or I(1). Meanwhile, the independent variables (regressors) can be stationary either at levels, I(0), or at the first difference, I(1). A unit root test was conducted to assess the stationarity and determine the order of integration of the variables. The results are reported in Table 3 which indicates that all variables are I(1).

Table 3: Unit Root Tests

Variables	ADF test		
	T-statistic		
	Level	Difference	Conclusion
Eti	-1.35	-12.76***	I(1)
Eui	-0.14	-7.45***	I(1)
Op	-0.58	-4.53***	I(1)
Os	2.38	-2.62**	I(1)
Ad	-1.84	2.41**	I(1)
Cvi	-0.73	-9.36***	I(1)
Cpu	1.60	-6.50***	I(1)

Source: Authors own calculation

Dynamic ARDL Simulation Model

Pertaining to the objectives of the study, Table 4 explains the results of the dynamic ARDL simulation models. The results show that the value of ECT is negative and significant, exhibiting convergence to equilibrium. Moreover, the results show that the energy-related uncertainty index has a long-term negative impact on ET, such that, a one percent increase in the energy-related uncertainty brings about a decrease of 0.27% in the process of the ET, whereas, during the short run, energy-related uncertainty index positively and significantly affects the ET process i.e. one percent increase in the energy-related uncertainty favorably bring about an increase of 0.19% in the ET process. However, oil prices in the long run exhibit a weak and insignificant impact on the energy transition process, and during the short run, it negatively and significantly affects the ET process in Australia, although the effect size is small

Moreover, oil supply positively and significantly affects the ET process during the long run, but negatively and insignificantly during the short run. In the long run, one percent increase in the oil supply brings about 0.012% increase in the ET process, whereas, in the short run, one percent increase in the oil supply brings about 0.0045% decline in the ET process. This shows that during the long run, higher oil prices facilitate the ET process in Australia. Otherwise, aggregate demand positively and significantly affects the ET process during the long run and short run. In the long run, a one percent increase in the aggregate demand brings about a 0.0010% increase in the ET process, whereas, in the short run, a one percent increase in the aggregate demand brings

about a 0.0006% increase in the ET process. The positive impact shows that heightened aggregate demand could incentivize investments in renewable energy technologies and other climate change adaptations, thereby fostering the ET (Maradin et al., 2017).

However, among the indicators of climate dynamics, the climate vulnerability index negatively albeit insignificantly affects the ET process both during the long run and short run, pointing out less responsiveness of the climate vulnerability index towards the ET process. Similarly, climate policy uncertainty negatively and significantly affects the ET process during the long run, such that, a one percent increase in climate policy uncertainty brings about a decrease of 0.12% in the transition towards renewable energy. But during the short run, climate policy uncertainty negatively and insignificantly affects the ET process. Overall, it can be concluded that ET is more responsive towards the energy market dynamics and less responsive towards climate dynamics. However, the results are further authenticated through the counterfactual analysis of the model presented in Figure 1.

Table 04: Response of ET to Energy Market Dynamics and Climate Dynamics

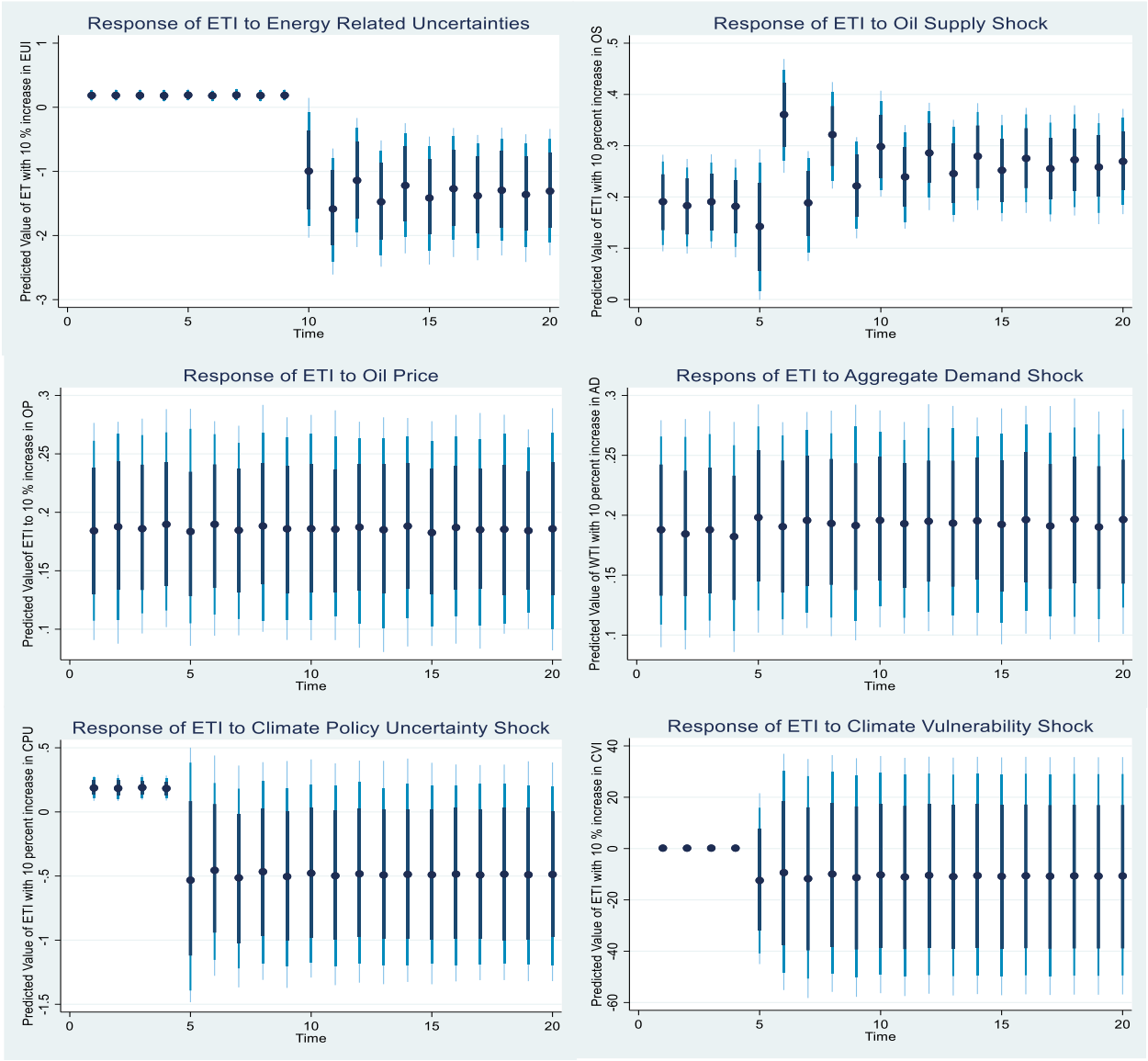
Model: $eti_t = \alpha_0 + \alpha_1 eui_t + \alpha_2 op_t + \alpha_3 os_t + \alpha_4 ad_t + \alpha_5 cvi_t + \alpha_6 cpu_t + \gamma_t$					
Variables	Coefficients				
ECT	-1.766*** (0.18)				
	Long run Results			Short run Results	
Eui	-0.27*** (0.05)			0.19** (0.05)	
Op	-0.0001 (0.00009)			-0.0002** (0.0001)	
Os	0.012*** (0.002)			-0.0045 (0.006)	
Ad	0.0010*** (0.0002)			0.0006* (0.0003)	
Cvi	-1.76 (2.451)			-1.15 (1.70)	
Cpu	-0.12** (0.046)			-0.07 (0.05)	
F-stat	10.30***			no. of obs	30
F-stat bound	I (0)	I (1)	cointegration	Root MSE	0.04
	2.82	4.80			
R2	0.90			Adj R2	0.80

Source: Authors' own tabulation of results obtained from dynamic ARDL model

Figure 1 portrays the results of dynamic ARDL post-estimation simulations when a positive 10% counterfactual shock is given to different indicators of energy market dynamics and climate dynamics at the time (t)=5. The first graph shows that a positive 10% counterfactual shock given to energy-related uncertainties positively influences the ET index during the short run but then declines to a predicted value of about -1% at t=5 and then manifests a mixed trend in the long run. The second graph illustrates the response of ET index to one of the major energy market dynamics i.e. oil supply shock. The counterfactual analysis shows that a positive 10% counterfactual shock to oil supply shock shows an increasing trend in the process of ET during the short run but then declines to a predicted value of about 0.13% at t=5, afterwards the ET process

becomes uncertain due to oscillations as shown in the graph over the long run. Whereas a positive 10% counterfactual shock given to oil prices allows the ET index to follow an increasing trend during the short run but then slightly declines to a predicted value of about 0.18% at t=5, thereafter, sustaining the steady trend over the long run.

Figure 1: Response of ETI to Energy Market Dynamics and Climate Dynamics



The response of the comprehensive ET index to aggregate demand shock shows that the process of ET follows the declining trend during the short run but then eventually increases to a predicted value of about 0.2% at t=5 and then sustains the steady trend over the long run. Similarly, the responsiveness of the ET index to climate policy uncertainty shows that a positive 10% counterfactual shock to climate policy uncertainty brings about a significant increase in the ET process during the short run, eventually declining to a predicted value of about -0.5% at t=5 and then following the steady trend during the long run. However, the last graph of Figure 01 shows that a positive 10% counterfactual shock given to the climate vulnerability index allows the

ET process to follow an increasing trend during the short run but then manifests a significant decline to a predicted value of about -20% over the long run.

3. Conclusion and Policy implications

This study provides a comprehensive evaluation of how energy market dynamics and climate policy uncertainties influence the energy transition in Australia. Using a novel Dynamic Autoregressive Distributed Lag (ARDL) simulation model, the findings reveal significant short-term and long-term effects of these factors on ET. Energy-related uncertainty and aggregate demand shocks positively drive energy transition in the short term, reflecting the potential for economic activity and policy interventions to stimulate renewable energy adoption. However, in the long term, energy-related uncertainty negatively impacts ET, underscoring the need for stability and strategic planning in the energy market.

Oil market dynamics emerge as critical determinants of ET, with oil supply shocks having a positive long-term effect while exhibiting mixed short-term results. This highlights the dual role of oil market fluctuations in both facilitating and hindering renewable energy adoption depending on the time horizon and the economic context. Aggregate demand contributes positively to energy transition in both the short and long term, demonstrating the importance of robust economic activity in fostering renewable energy investments. However, oil prices and climate vulnerability show limited responsiveness to ET, indicating that these factors, while relevant, are not as impactful in shaping Australia's energy landscape. Conversely, climate policy uncertainty negatively affects energy transition in the long run, signaling the detrimental role of regulatory unpredictability in renewable energy investment and infrastructure development. The findings emphasize that while energy market dynamics are the primary drivers of ET, the role of climate-related dynamics, particularly policy frameworks, cannot be disregarded. A clear and stable regulatory environment is essential to mitigate uncertainty, encourage private sector investments, and ensure sustained progress toward decarbonization.

Policy implications from this study suggest that to accelerate the energy transition, Australia must prioritize reducing regulatory uncertainties, fostering innovation in renewable technologies, and maintaining consistent support for clean energy projects. Policymakers should also focus on integrating robust climate policies with economic

incentives to create a synergistic effect that supports both environmental and economic objectives. Future research could expand on this work by exploring cross-country comparisons, examining the influence of technological advancements, and incorporating global supply chain dynamics into the analysis. Additionally, further investigation into the interaction between fiscal and monetary policies with energy transition efforts could provide deeper insights. By addressing the identified barriers and leveraging the opportunities, Australia can achieve a sustainable energy future, balancing economic growth with environmental stewardship.

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