

Article

A Study on the Driving Mechanism of Chinese Oil and Gas Companies' Transition to Renewable Energy

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Abstract: Encouraging oil and gas (O&G) companies to develop renewable energy sources (RESs) is crucial for China's energy strategy and sustainable development. The transition from O&G energy to RESs is a complex and systemic process that requires a comprehensive analysis of both internal and external driving factors. This study integrates the theoretical dimensions of energy transition with the operational realities, utilizing structural equation modeling (SEM) to analyze these factors and their influence on the decision-making process for companies in this sector. A multi-group analysis was conducted to explore differences in motivational mechanisms among groups with varying levels of transition willingness. The findings reveal that environmental awareness, economic value estimation, knowledge accumulation, dynamic capabilities, structural overlap, and government actions significantly promote the energy transition, whereas resource endowment acts as a barrier. Moreover, the willingness to transform moderates the effects of government actions and pressures from other stakeholders on corporate environmental awareness and the transition to RESs. This article provides more comprehensive research perspectives on exploring the driving mechanisms behind the transition to renewable energy, emphasizing the importance of governments playing diverse roles based on the specific internal conditions and highlighting the long-term impact of other stakeholders on sustainable development.

Keywords: energy transition; renewable energy resource; oil and gas company; structural equation modeling



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1. Introduction

Globally, the vigorous development of RESs has become a core strategy for combating climate change and promoting energy transition, and this direction has garnered widespread support from the international community [1]. As this trend continues to strengthen, traditional energy companies are increasingly venturing into the renewable energy sector and accelerating carbon emission reduction, which is a common practice for promoting their own sustainable development and integrating into the new energy system [2]. In this context, the Chinese government has exerted a positive influence by implementing a range of policies that encourage the convergence of traditional energy sectors with RESs. Moreover, it is hastening the green and low-carbon transition of energy enterprises, thereby constructing an energy system that is characterized by cleanliness, low carbon emissions, security, high efficiency, and a mutual complementarity of strengths [3]. After decades of development, China has established technological leadership and the capacity for large-scale development in the arenas of renewable energy production, storage, transmission, and utilization. Concurrently, the nation has achieved significant success in promoting renewable energy consumption, improving public welfare, and expanding international cooperation [4]. These achievements have laid a solid foundation for the sustainable and high-quality evolution of the energy sector.

In academic discussions on energy transition, the role and capabilities of O&G companies have consistently been a focal point of research. On one hand, there is a perspective that O&G companies act as resistors in the energy transition process, utilizing strategies such as their authority, economic resources, technical capabilities, discourse frameworks, and institutional rent-seeking to oppose low-carbon transitions [5–7]. Some studies also reveal a gap between the intentions and actions of O&G companies during their transition to cleaner energy. Although some O&G companies assert that they are committed to transformation, their actual steps have not fully aligned with these declarations [8,9]. To craft their public image [8], companies often employ frameworks such as Tech-no-optimism, Necessitarianism, Compliance, and Countermeasures. However, these approaches may fall short in tackling the complex challenges posed by climate change. This tactic of portraying a greener image than is actually practiced, known as ‘greenwashing’ [10,11], could be attributed to various factors, including the political systems, economic contexts, socio-cultural influences, and technological capabilities inherent within the O&G industry [12]. However, these perspectives have not fully considered the diversity and complexity of O&G companies, as well as their adaptation to successive challenges and disturbances [13]. Recently, an increasing number of scholars have begun to recognize the potential positive role that O&G companies can play in energy transition and have reassessed their contributions to combating climate change. Research conducted by Morgunova and Shaton [14], through surveys on the attitudes and strategies of O&G companies towards energy transition, as well as their stance and contributions to climate change, reveals the potential of O&G companies in the energy transition. Chaiyapa et al. [15] suggests that O&G companies can play a key role in the transition to low-carbon development in lower- and middle-income countries. Researchers in the field of energy transition are striving to gain a deeper understanding of the performance of incumbent O&G enterprises during the transition period [16]. Their core concerns include the motivations [17] for O&G companies to develop RESs, their strategies [18,19], and the opportunities and challenges [20–22] they face. Additionally, research has indicated the presence of knowledge spillover [23,24], path creation [25–27], path dependence [27,28], and technological lock-in [29,30] between the incumbent business units of O&G companies and the emerging renewable energy sectors. These research areas are not only set against a common theoretical and practical backdrop but also carry significant practical implications in the context of addressing climate change and geopolitical crises.

Existing studies have relatively few in-depth analyses of the mechanisms and actual effects of internal and external factors in the transformation process. Furthermore, despite recognizing the existence of phenomena such as knowledge overflow and technological lock-in, there is still a lack of specific empirical research on how to effectively promote this transformation process, especially in large energy-consuming and energy-producing countries like China. As the global call for green transformation grows louder, governments and academia are emphasizing the pivotal role of O&G companies in driving energy transition and achieving sustainable development. Although O&G enterprises worldwide have taken various actions in developing a “new renewable” energy industry, numerous challenges and issues persist. We need to conduct a more in-depth analysis of the mechanisms and actual effects behind these measures [30] to ensure that they can make a substantial contribution to the company’s sustainable and green transformation.

Therefore, this study delves into and assesses the internal and external factors influencing the transition of Chinese O&G enterprises to renewable energy through a combination of theoretical analysis and empirical research. Specifically, this paper will employ the structural equation modeling (SEM) as the primary research tool, integrating survey data from traditional energy enterprises in China to empirically test the mechanisms by which internal and external motivational factors influence the energy transition behaviors of O&G companies. It aims to reveal and quantify the impact of these factors, in order to understand and promote energy transition in China and globally.

2. Hypothesis and Theoretical Model

Against the backdrop of the global energy structure transition, O&G companies are facing unprecedented operational pressure to transform their energy practices. The behavior of energy transition is not only a response to external pressures but also a result of well-considered strategic planning, representing a planned and rational action. The behavior involves processes such as investment in new technologies, the development of new markets, and the reshaping of organizational culture, which is closely related to the company's internal factors and external environment. In this study, we focus on exploring a series of key factors—environmental awareness, resource endowment, knowledge accumulation, government actions, structural overlap, dynamic capabilities, pressure from other stakeholders, and economic value estimation—on how they influence the green transformation behavior of O&G companies.

2.1. Environmental Awareness, Economic Value Estimation, and the Transition to RESs

Enterprises are composed of individuals with “bounded rationality,” whose behaviors are influenced by cognitive biases and personal values [31,32]. According to the theory of planned behavior, behavioral attitudes reflect the actor's judgment of the potential behavior outcomes and their assessment of the potential value of these actions [33]. The company's behavioral attitude is key to its decision-making process. It not only reflects the awareness of environmental responsibility but also demonstrates an assessment of the economic potential following energy transition and an adaptation to market trends. This, in turn, affects the company's strategic choices and long-term sustainability. In the context of O&G companies transitioning to RESs, we believe that their behavior and attitudes are primarily influenced by two key factors. First, the evaluation of the economic value of RESs, which involves the recognition of the potential of the RES market and the prediction of future benefits. Second, there is the internal environmental awareness within the company, reflecting its commitment to sustainable development and environmental protection. The formation of this attitude is not only related to the company's judgement of the renewable energy market but also shows the company's willingness to take action to support broader environmental and social responsibilities.

Certainly, O&G companies will definitely consider the economic value brought by the development of the RES industry in their strategic planning regarding RESs. Against the backdrop of continuous technological breakthroughs and scaled production in the renewable energy sector, the development costs of RESs are gradually decreasing, providing strong support for the economic feasibility of RES projects. At the same time, the development of RESs is expected to bring stable, long-term cash flows [29], which can hedge some of the price risks faced by the O&G industry [34]. Therefore, O&G companies will improve their profitability in response to energy transition by identifying and utilizing opportunities in the RES market, such as by developing new RES products that meet consumers' demand for environmentally friendly products [35].

At the same time, environmental awareness is of undeniable importance within companies and has gradually become the core driving force for companies to take ecologically responsible actions. Companies motivated by ecological responsibility often make decisions based on strong personal or organizational values [35]. These values guide the company to operate in a more environmentally friendly manner, transcending traditional decision-making paradigms. Research indicates that a company's attention to environmental issues and proactive environmental protection actions are key to the successful green transformation of energy companies [36,37]. Voluntary and autonomous environmental initiatives by employees are increasingly seen as crucial to achieving outstanding environmental results for companies [38,39]. The enhancement of internal environmental awareness within a company can serve as a model [37], encouraging employees to engage with environmental issues [38,40], promoting the implementation of more formal environmental practices [37], and improving environmental performance [37]. This can strengthen the company's reputation for sustainable development [35] and its ability to cultivate

future markets [41]. The attitude of managers towards environmental issues, whether they perceive them as threats or opportunities, profoundly influences the company's pursuit of innovative environmental technologies. When managers view environmental issues as opportunities, the company is more likely to adopt voluntary environmental strategies, thereby promoting the innovation and application of environmental protection technologies [42]. Additionally, environmentally friendly RESs, as a prominent field in the rise of environmental awareness and environmental practices, provides an effective pathway for O&G companies to achieve environmental transformation. Sharma [43] and Hartmann et al. [44] have confirmed in their research that there is a connection between the interpretation of environmental issues by managers in O&G companies and the company's choice of environmental strategies; the more experience a company accumulates in environmental protection, the more it helps to increase the commitment of corporate management to RESs. Even under the pressure of industry standards and regulations, companies can still exercise strategic choices by adopting voluntary environmental strategies that exceed regulatory requirements. This choice not only meets the growing consumer preference for environmentally friendly products but also helps companies discover new areas of innovation and maintain a competitive advantage in the long term. Companies that place sustainability at the core of innovation can effectively respond to environmental challenges and explore new markets and business models, achieving dual benefits for the economy and the environment [41]. As corporate environmental awareness continues to strengthen, they are more likely to take action in key areas such as climate change and energy transition and to explore new investment opportunities, including RESs, thereby promoting global environmentally sustainable development.

2.2. Government Actions, Pressure from Other Stakeholders, and the Transition to RESs

During the execution of a specific decision-making process, enterprises are subject to certain external pressures, primarily stemming from various stakeholders. In the process of the O&G industry's transition to renewable energy, the government and other stakeholders (including investors, the public, and peer companies, among others) play both an exemplary role and provide a certain degree of supervision and guidance for the actions of O&G companies. The government's proactive advocacy and the introduction of regulatory policies create an atmosphere for energy transition that can enhance the environmental awareness of O&G companies, thereby positively influencing their environmental actions and encouraging their transformation RESs.

Concurrently, public oversight, the demands of investors for environmentally friendly business practices, and the exemplary transitions of peer companies also contribute to shaping the environmental awareness of O&G companies, promoting their active response and the taking of action. In the analysis of the strategic investments in RESs by four major oil companies, Kenner [30] confirmed that decisions made at the personal level by corporate decision makers play a crucial role in the process of corporate energy transition. However, it is also necessary to rely on external pressures, particularly the impetus from government pressures, to enhance the proactivity of decision-makers in carbon reduction initiatives. Simultaneously, the public's perception is of paramount importance to the operation of O&G companies [45], as it is directly linked to their corporate social image and reputation. The public's expectations and pressures regarding energy transition and carbon emission reduction exert a significant influence on O&G companies. This societal-driven force compels enterprises to pay close attention to and address the concerns of the public.

Similarly, the expectations and actions of stakeholders have a significant impact on the economic value estimation and transformation behavior of O&G companies in the field of RESs. Government policy direction and incentive mechanisms, such as subsidies and tax incentives for the RES industry, can directly affect the economic expectations of O&G companies for renewable energy projects, enhancing their willingness to invest in RESs. The carbon emission standards and reduction targets set by the government, through establishing market mechanisms like carbon trading or cap-and-trade systems, provide

economic incentives to reduce greenhouse gas emissions. These measures highlight the economic advantages of RES projects by making traditional energy production and consumption more expensive. The emphasis on environmental, social, and governance (ESG) by investors also prompts O&G companies to pay more attention to the economic potential and long-term returns of RES projects. As investors' preference for low-carbon economy investments grows, O&G companies are more inclined to consider the environmental benefits and social responsibilities when evaluating RES projects, which helps to enhance the green economic value of these projects. The demonstration effect of peer companies' transition to RESs, by showcasing successful cases and the economic benefits of RES projects, provides a reference and the confidence for O&G companies to transform. This kind of healthy competition and cooperation within the industry can stimulate O&G companies to re-evaluate the economic value of RESs and accelerate their transformation pace. Finally, the increasing public demand for renewable and clean energy, along with concerns about the environmental impact of traditional energy, poses market pressure and opportunities for O&G companies. Changes in public expectations and preferences compel O&G companies to re-examine the market potential and the consumer value of RESs, thereby affecting their economic value estimation and investment decisions for RES projects.

2.3. Knowledge Accumulation, Structural Overlap, and the Transition to RESs

Amidst profound global shifts in the energy structure, O&G companies are at a crossroads of transformation. At this critical juncture, understanding and leveraging a company's comparative advantages are essential for capturing opportunities in the RESs market. The theory of comparative advantage suggests that the competitive edge a company develops in a specific domain due to the accumulation of technology, knowledge, or resources can be key to its success in new markets or fields.

Path creation theory posits that before new paths emerge, the existing knowledge, experience, and resources in the economy play a dominant role in path creation [46]. In recent years, evolutionary economic geography (EEG) has increasingly recognized firms and entrepreneurs as key agents in path creation [47,48], with businesses enhancing their capabilities through the accumulation of knowledge [49]. The accumulation of organizational knowledge provides a comparative advantage for new strategic choices of the company, as it can form a resource pool to fill existing knowledge for the development of new business areas [44]. A substantial amount of research has confirmed the positive role of corporate knowledge accumulation in corporate strategic selection and capability development, encompassing experience gained in activities such as mergers and acquisitions, investment, research and development, operations, and management. In the energy sector, Hartmann et al. [44] has demonstrated that the specific knowledge that O&G companies accumulate through the internal use of RESs, environmental protection practices, and participation in international markets can positively influence their commitment to developing RESs. International oil companies can attract cooperation with start-ups related to RESs by emphasizing their professional and unique experience in the energy market. For example, Total particularly emphasizes its experiential knowledge in the African energy market, and Shell highlights its ability to readily access practical experience and "local" corporate knowledge. Despite the challenges of technological barriers, market volatility, and the regulatory risks that O&G companies face when investing in the new energy sector, their extensive knowledge from large-scale O&G production is undoubtedly a valuable asset. This accumulated expertise can effectively reduce the initial entry barriers, lower certain costs, and enhance the profit potential in the renewable energy field [50]. Consequently, knowledge accumulation can represent a significant influencing factor for O&G companies' choices regarding RESs. However, the role of knowledge accumulation in the process of corporate transformation is sometimes more complex. The experience and knowledge of existing highly skilled employees in O&G companies is largely centered around traditional fossil fuels, and the difficulty in transferring technical expertise and knowledge makes it difficult for employees to quickly adapt to the needs of RES technologies. Additionally,

organizational inertia can make it hard for companies to break away from existing work methods and modes of thinking, adopting a conservative stance towards new approaches and innovation. Moreover, conflicts in culture and values may lead to a lack of identification with the sustainable development goals of RES business among employees. Thus, the shift towards RES business also poses a significant challenge for them [44,51]. Consequently, while knowledge accumulation can be an important influencing factor for O&G companies' choices of RESs, the direction of its influence remains uncertain.

One of the prerequisites for traditional energy companies to achieve the integrated development of RESs and conventional O&G business is the similarity in work content and the overlap in business structure between the two industries. The O&G sector and the new energy sector exhibit structural overlaps in areas including technology, institutional standards, and networks of stakeholders [52]. Firstly, there is a high degree of technological similarity between O&G energy and RESs. A survey by the International Energy Agency (IEA) shows that approximately 40% of offshore wind power construction projects overlap with offshore O&G projects. The synergistic development of the two industries facilitates O&G companies in fully transforming and leveraging their existing infrastructure, labor force, equipment, and technology, and other factors of production in the development of RES businesses, thereby effectively reducing the costs associated with the advancement of RESs [53]. For instance, the traditional floating platform technology for O&G can be adapted for the construction of offshore wind power projects, and marine engineering, deep-water development, and drilling technologies can be applied to the construction of deep-water floating wind power. In terms of standards, both exhibit a high degree of similarity in their technical and safety specifications. The lifecycle technical specifications formed by the O&G industry over the long term, including engineering design, manufacturing, construction, and operation and maintenance, are all reference-worthy for the RES industry. The maintenance and overhaul of RES equipment, such as wind power, can also fully draw on standards from the O&G industry. In terms of stakeholder network relationships, there is also a high degree of overlap between the O&G sector and the RES sector in terms of government departments, electricity companies, research institutes, and the other network relationships involved. The structural overlap between the two allows energy companies to reduce a portion of costs when developing RES businesses, thereby enhancing the expected profits. It also reduces development risks to a certain extent, allowing energy companies to start "a second entrepreneurship" at a high level and accelerate the development of RES business. However, given that the current technologies, standards, infrastructures, and stakeholder networks of O&G companies are predominantly configured for traditional fossil fuel operations, there exists a degree of inertia within these existing resources that may impede the intentions and actions of these companies in advancing renewable energy initiatives [44,51]. The assets of O&G firms, including wells, pipelines, and refineries, which are tailored for the processing of fossil fuels, could incur significant costs associated with re-tooling for the renewable energy sector, thereby dampening their investment enthusiasm, particularly in scenarios where short-term returns are not evidently forthcoming. Consequently, the structural congruence between conventional and renewable energy endeavors may exert an influence on the inclinations and activities of O&G companies in their transition endeavors, yet the precise direction of this impact remains indeterminate.

2.4. Resource Endowments, Dynamic Capabilities, and the Energy Transition to RESs

A firm's resource endowment and dynamic capabilities are core concepts in strategic management; together, they form the foundation of competitive advantage and play an essential role in the development and transformation of the enterprise. Driven by globalization and technological innovation, the energy sector is undergoing an unprecedented transformation. O&G companies, as the primary suppliers of traditional energy, must now re-evaluate their strategic direction to adapt to the development of the RES market. It is

evident that a firm's resource endowment and dynamic capabilities are the safeguards for its response to market changes and the realization of strategic transformation.

Resource endowment is a necessary precondition for economic development [48], a principle substantiated within the traditional international trade theory [54]. Confronted with external threats and pressures for transformation, decision makers make optimal responses based on clearly available resources and capabilities. Given the "ecological uncertainty" of O&G resources [55], O&G companies may opt to invest in renewable energy as a hedging strategy [44]. The motivation for O&G enterprises to invest in new energy and undergo a green, low-carbon transformation is influenced by the volume of internally discoverable O&G resources [56,57]. Companies with lower levels of discovered O&G reserves tend to move into the new energy sector more swiftly and completely [57]. In contrast, enterprises with higher levels of discovered reserves are often more inclined to promote the integrated development of O&G as a transitional strategy for evolving into integrated energy companies. Well-capitalized O&G companies have a strong risk resistance to the research and development of and the investment in new energy. However, due to the existence of their current O&G operations, technological research and development tends to focus around core business activities, making it challenging to achieve disruptive innovation in the new energy sector, leading to a potential technological lock-in [29]: a point confirmed by Oberling in the context of O&G companies' investment in liquid biofuels [29]. Therefore, this study incorporates the resource endowments of O&G companies into the analytical framework to examine their role in shaping the willingness and mechanisms of action for the development of new energy industries by these companies.

Dynamic capabilities are defined as "the ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing markets" [58]. This notion extends the Resource-Based View (RBV), offering a new perspective for understanding how firms can maintain and renew their competitive advantage in dynamic environments [59]. Dynamic capabilities form the foundation for firms to continuously adapt and innovate in turbulent environments [60]. Strong dynamic capabilities can enhance a firm's strategic agility, which is key for seizing opportunities and profiting in new business contexts. In the process of energy transition, O&G companies need to face complex business management activities, such as formulating new strategies, establishing new partnerships, managing joint ventures or mergers and acquisitions, developing and deploying new technologies, rapidly learning new expertise, and assessing health and environmental risks. Strong dynamic capabilities can guide these activities and help companies make precise decisions [61]. O&G companies need a range of dynamic capabilities in the energy system transition, including organizational management, strategic investment, research and development, and learning capabilities [2]. These dynamic capabilities not only help companies adapt to new trends in the energy market but also enable them to play a leading role in energy transition. Moreover, O&G companies have the ability to flexibly switch and balance between traditional O&G business areas and emerging renewable energy fields [61]. Through the dynamic capabilities of integrating and reconfiguring resources, O&G companies can effectively mobilize and utilize internal and external resources to support the development of renewable energy projects, enhance strategic adaptability, quickly identify and respond to opportunities and challenges in the renewable energy market, accelerate the learning and innovation process, quickly master renewable energy technologies, and promote knowledge innovation, ensuring the continuous maintenance of their competitive advantage in the renewable energy field. Thus, it is reasonable to believe that the dynamic capabilities of O&G companies have a significant impact on their transition towards renewable energy and could become a key factor in driving traditional energy enterprises towards low-carbon and sustainable development.

2.5. The Transition to RESs

Government policy guidance, market incentives, and the internal knowledge, structure, resources, and capabilities of enterprises provide favorable conditions for green

transformation in O&G companies. The proactive response and effective actions of these companies are key to achieving this transition. O&G companies have taken a series of specific actions during the transition to renewable energy, which not only reflect the significance of the transition but are also crucial steps towards green development. Firstly, strategic development transformation is evident as O&G companies formulate green development strategies, actively invest in and develop RES projects, reduce their reliance on traditional O&G operations, optimize their business structure, mitigate market volatility risks, and explore the RES market. Secondly, the transformation of production methods involves developing clean energy to achieve green substitution in production energy use, effectively reducing greenhouse gas emissions and operational costs, and promoting a shift towards low-carbon and emission reduction in O&G development. For example, integrating clean electricity and wind power technology into O&G platforms, pursuing an integrated development path with RESs, and reducing the use of fossil fuels for power supply.

Simultaneously, talent development and acquisition have become crucial elements of the transition process. O&G companies are intensifying the cultivation and recruitment of talent in the RES sector, optimizing the human resource structure, and establishing a talent pool for renewable energy to provide intellectual support for the company's green transition. Technological innovation is the core driving force behind the renewable energy transition of O&G companies. Currently, these companies are accelerating the application and implementation of CCUS (Carbon Capture, Utilization, and Storage) technology, exploring technical and economic pathways for carbon capture and sequestration. Additionally, they are improving existing technologies to enhance the efficiency and environmental friendliness of O&G extraction and production processes, reducing energy consumption and greenhouse gas emissions. Active participation in the research and development of RES technologies, such as solar, wind, and geothermal energy, is ongoing, with strengthened technical exchanges and the sharing of successful cases and innovative concepts with international partners. O&G companies are constructing multi-energy complementary facilities, like wind and solar power generation, hydrogen energy, and geothermal energy, as well as source–network–load–storage and microgrid systems, serving as complementary capacity constructions for O&G development projects. The O&G companies are also continuously promoting cross-industry technological integration, exploring the combination of technologies between the O&G industry and other industries, and developing new energy application scenarios and business models, providing new development opportunities for the RES transition of O&G companies. In summary, the RES transition behaviors of O&G enterprises encompass strategic, production, talent, and technological innovation dimensions, providing strong support for the sustainable development of the enterprise.

2.6. Hypothetical System

Based on the theoretical analysis of the motivational mechanism presented above, the following hypotheses were proposed:

- H1.** *Government actions positively impact the environmental awareness of O&G companies.*
- H2.** *Pressure from other stakeholders positively impacts the environmental awareness of O&G companies.*
- H3.** *Government actions positively impact the economic value estimation of RES development by O&G companies.*
- H4.** *Pressure from other stakeholders positively impacts the economic value estimation of RES development by O&G companies.*
- H5.** *Knowledge accumulation positively impacts the economic value estimation of RES development by O&G companies.*

H6. Structural overlap positively impacts the economic value estimation of RES development by O&G companies.

H7. Governmental actions positively impact the transition to renewable energy sources of O&G companies.

H8. Pressure from other stakeholders positively impacts the energy transition behavior of O&G companies.

H9. Knowledge accumulation impacts the energy transition behavior of O&G companies, with the direction of influence potentially being positive or negative.

H10. Structural overlap impacts the energy transition behavior of O&G companies, with the direction of influence potentially being positive or negative.

H11. Resource endowments negatively impact the energy transition behavior of O&G companies.

H12. Dynamic capability positively impacts the energy transition behavior of O&G companies.

H13. Environmental awareness positively impacts the energy transition behavior of O&G companies.

H14. Economic value estimation positively impacts the energy transition behavior of O&G companies.

2.7. Theoretical Model

Based on the research hypotheses, a theoretical model was constructed that reflects the joint influence of internal and external factors on the transition of O&G companies towards RESs, as shown in Figure 1.

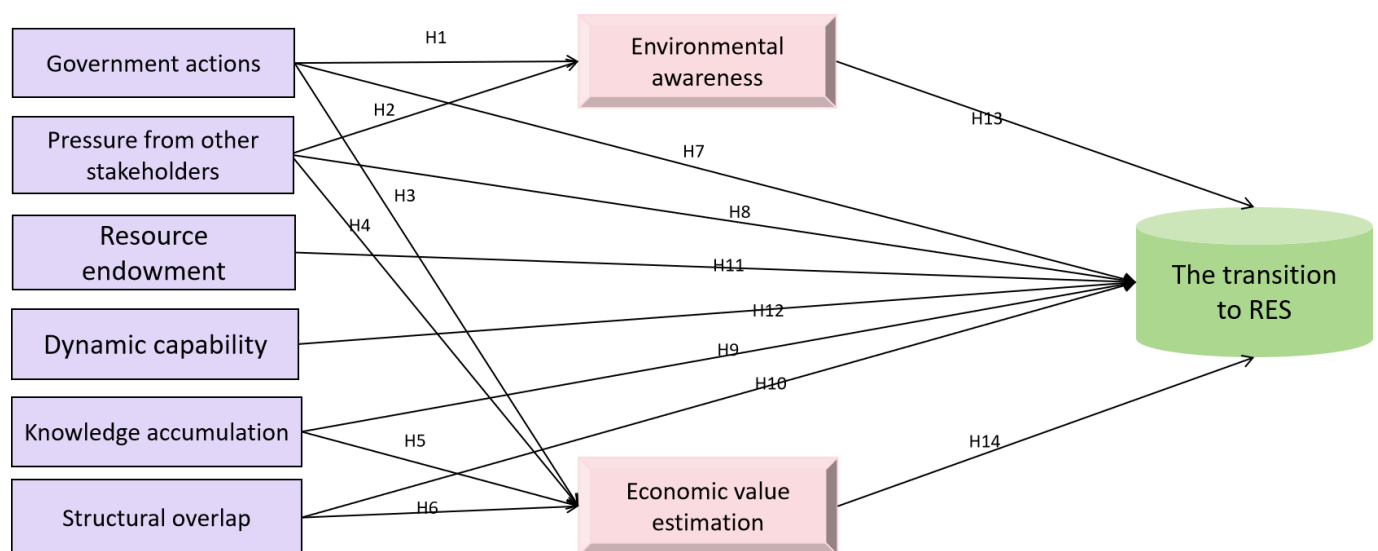


Figure 1. Proposed research model.

3. Research Method

3.1. Questionnaire Design and Data Collection

According to the company analysis data from the China Security Market Accounting Research (CSMAR) database (2024), there are currently approximately 50–100 specialized O&G companies in China. These companies are primarily involved in the business areas of O&G exploration, refining, and trade, as well as oilfield service engineering. However, it should be noted that the number of companies indirectly involved through supplier link-

ages is uncertain. Referring to the qualitative research methods employed by scholars [24], from February 2023 to May 2024, we conducted a questionnaire survey of 48 companies and organizations related to the O&G industry using a combination of online and offline methods. The surveyed entities mainly included 28 specialized O&G companies, as well as research organizations and personnel in the energy field, venture capital companies, and utilities. The list of companies and organizations involved in the survey is shown in Table 1.

Table 1. List of interviewed firms/organizations.

Firms/Organization Type	Firms
O&G companies (28)	CNPC, CNOOC, Sinopec, Blue Flame, Potential Energy, Sino Prima Gas, Guanghui Energy, Geo-Jade Petroleum, Xinchao Energy, Taishan Petroleum, Heshun Petroleum, ZPEC, BOMESC, Guanghui Energy, CPEC, Hengli Petrochemical, HY Energy Group, COSL, Sinopec Shanghai Petrochemical, Geo-Jade Petroleum Corporation, Tongkun Group Co., Ltd., China Oil HBP Science & Technology Co., Ltd., Zhejiang Renzhi Co., Ltd., Beiken Energy, Yussen Energy, Tong Petrotech Corp, SINO Geophysical, Daming Petroleum, Oriental Energy Co., Ltd.
Other firms/organizations (20)	Venture capital firms (3), energy research institutions (6), renewable energy firms (3), utilities (4), multi-industry supply firms (4).

Within the established research framework, the preliminary survey questionnaire selected 44 items based on previous studies. Subsequently, specialists in the respective fields were invited to review and revise this survey. To ensure reliability, the questionnaire underwent two pilot tests and a Cronbach’s alpha analysis, ultimately forming a questionnaire containing 39 items, as detailed in Table 2. In the end, we collected data from 1100 respondents (for more detailed information, see Table 3). After screening, 649 valid questionnaires were determined, with an effective recovery rate of 59%. All the participants were asked to rate all questions in the questionnaire using a five-point Likert scale (1 = “Extremely disagree”, 5 = “Extremely agree”).

Table 2. Questionnaire items in the main survey.

Constructs	Descriptions	References
Environmental awareness	A1: The O&G companies engage in discussions about climate change within their annual reports and routine meetings, acknowledging environmental incentives and rewards, and referencing environmental ratings. For example, does the company report on its progress in reducing greenhouse gas emissions?	[44,62]
	A2: The O&G companies proactively undertake environmental initiatives and campaigns as part of their daily operations. For example, has the company implemented projects to reduce waste or improve energy efficiency?	
	A3: The O&G companies have established environmental training programs, integrated performance metrics that prioritize environmental considerations, and published sustainability reports. For example, does the company offer training sessions on environmental management?	
	A4: The remuneration of management in O&G companies takes into account environmental performance. For example, does the company tie the achievement of environmental targets to its executives’ bonuses?	
	A5: Employees of O&G companies actively participate in environmental activities organized by the company, stay informed about the company’s environmental plans, and engage in the company’s organized environmental activities. For example, do employees participate in tree planting or cleanup events organized by the company?	

Table 2. Cont.

Constructs	Descriptions	References
Economic value estimation	B1: The anticipated profitability of RES is driving O&G companies to develop their RES business. For example, has the potential for long-term cost savings through solar or wind energy projects influenced the company's decision to invest in RES?	[12,14,44,63]
	B2: The gradual decrease in the costs of RES is encouraging O&G companies to expand their engagement in RES initiatives. For example, has the company considered investing in RES due to the recent reductions in the cost of solar panels or wind turbines?	
	B3: The increasing uncertainty in the fossil fuel market is prompting O&G companies to diversify into RES ventures. For example, has the volatility in oil prices led the company to explore more stable energy sources like RES?	
Governmental actions	C1: Measures by the government to increase the production costs of fossil fuels are likely to incentivize O&G companies to pursue RES business development. For example, has the company responded to carbon taxes or levies by increasing investments in RES?	[64–66]
	C2: Governmental regulations limiting carbon emissions are likely to propel O&G companies towards the expansion of their RES business. For example, has the company's strategy been influenced by China's "Dual Control" system for energy consumption and carbon emissions?	
	C3: The national emphasis on energy security is a catalyst for the transformation of O&G companies towards RES. For example, has the company taken steps to invest in RES in response to national policies aimed at reducing dependence on imported fossil fuels?	
Other stakeholders pressure	D1: The progress made by peer companies in transitioning to RES serves as a demonstrative influence on O&G companies in their pursuit of a similar transformation.	[15,67–69]
	D2: The capital market's increasing investment interest in clean energy projects, coupled with a waning interest in traditional O&G operations.	
	D3: The growing market demand for clean energy, along with consumer preferences for environmentally friendly energy sources, is prompting O&G companies to contemplate a shift towards RES.	
	D4: The development of RES is advantageous for maintaining a social license to operate within local communities and among the broader public.	
Knowledge accumulation	F1: The expertise in engineering design and construction, as well as the accumulated knowledge in the exploration domain, of O&G companies provide a significant advantage for the development of RES projects. For example, does the company leverage its experience in offshore drilling to develop offshore wind projects?	[70–72]
	F2: The knowledge accumulated in operations and maintenance management by O&G companies can contribute to enhancing the operational efficiency and long-term sustainability of RES projects. For example, does the company apply its expertise in managing large-scale equipment maintenance to service wind turbines or solar panels?	
	F3: The professional knowledge and experience in the energy market of O&G companies can effectively attract cooperation with startups related to RES. For example, has the company partnered with a startup to develop innovative energy storage solutions utilizing its market knowledge?	[70–72]
	F4: Through the knowledge accumulation of management and employees, O&G companies have effectively created new pathways for RES business development. For example, has the company used its project management skills from oil and gas pipeline development to initiate new geothermal energy projects?	
	F5: The knowledge accumulated in the O&G industry by companies assists in better assessing and managing the risks associated with entering the RES market. For example, does the company use its risk assessment methodologies from oil exploration to evaluate the financial risks of investing in solar energy farms?	

Table 2. Cont.

Constructs	Descriptions	References
Structure overlap	G1: The development of RES technology in O&G companies is inspired by O&G technology.	[24,50]
	G2: The RES business of O&G companies can draw on the standards and governance standards of O&G production. For example, does the company use its established health, safety, and environmental (HSE) protocols from oil operations to govern its solar or wind energy projects?	
	G3: Suppliers in the O&G sector of O&G companies can follow their clients into the RES market. For example, are suppliers that traditionally provided equipment for oil rigs now providing materials for offshore wind turbine construction?	
	G4: The government networks involved in the O&G sector of O&G companies can be transferred to the RES sector.	
Resource endowments	H1: The magnitude and quality of O&G reserves may influence the positioning of O&G companies within the RES market, as well as the transformation strategies and pace they opt for.	[69,73]
	H2: High-quality human resources can drive the development of new technologies and the improvement of existing ones, accelerating the advancement of RES technologies.	
	H3: The substantial capital of O&G companies provides the necessary financial support for RES projects, aiding in the expansion of production scales and the acceleration of market penetration.	
	H4: The advanced technological resources and robust infrastructure possessed by O&G companies can contribute to enhancing the operational efficiency, reducing costs, and improving competitiveness of RES projects.	
	H5: The enhanced brand and market image of O&G companies are beneficial for increasing their influence in the RES market.	
Dynamic capability	Q1: Marketing Capability: The marketing strategies of O&G companies effectively enhance the market acceptance of RES products.	[2,56,74]
	Q2: Research and Development Capability: The R&D capabilities of O&G companies possess a competitive edge in the field of RES technology.	
	Q3: Learning Ability: The strong learning capacity of O&G companies aids in identifying and managing risks associated with the transition to RES.	
	Q4: Organizational Culture: O&G companies have cultivated a culture of continuous learning and improvement, enabling them to swiftly adapt to the changes in the RES market and technology.	
The transition to RES	Y1: The O&G companies have formulated clear energy transition strategies and have made investments for future entry into the RES market (such as R&D projects, facilities, or the establishment of specialized RES companies).	[21,75,76]
	Y2: The O&G companies are intensifying efforts to tackle key core technologies, accelerating breakthroughs in new theories and technologies in RES.	
	Y3: The O&G companies are continuously promoting cross-industry technological cooperation, attempting to discover new industrial growth points through the RES industry.	
	Y4: The O&G companies are currently engaged in the development and implementation of schemes such as powering O&G platforms with RES, thereby advancing the integrated development of O&G and RES.	
	Y5: The O&G companies are strengthening the cultivation and introduction of talent in the RES field, enhancing team building in talent, and accelerating the reserve and training of high-skilled talents for new businesses.	
	Y6: The O&G companies are constructing complementary RES facilities such as source-network-load-storage and microgrids.	

Table 3. Demographic information.

Age	n (%)	Education	n (%)
<25	20.3%	Specialized	28.6%
Between 26 and 35	21.4%	Bachelor's degree	46.8%
Between 36 and 45	16.4%	Master's degree or above	24.5%
Between 46 and 55	18.1%	Company size	n (%)
>56	23.8%	<100	13%
Position	n (%)	Between 100 and 149	27.2%
CEO/general manager	23.1%	Between 150 and 299	26.6%
Senior executive/other manager	62%	Between 300 and 499	18.9%
Production manager	9.9%	>500	14.3%
Information not available	5%		

3.2. Structural Equation Modeling

Studies within the literature have demonstrated that structural equation modeling (SEM), as a multivariate data analysis instrument, possesses significant advantages in examining the relationships among variables [75]. Therefore, this study employs SEM to delineate and quantify the comprehensive impact of factors such as environmental awareness, resource endowment, and knowledge accumulation on the transition of O&G companies towards RESs. SEM is comprised of two components: the measurement model, which elucidates the relationship between latent variables (e.g., environmental awareness, resource endowment, and knowledge accumulation) and their corresponding observed indicators; and the structural model, which assesses the direct and indirect associations among latent variables.

Consequently, this study utilizes SEM, integrating observed and latent variables, to test the theoretical model of the decision-making mechanism for renewable energy transition in O&G companies and to evaluate the robustness of the hypotheses. In this research, the theoretical model developed encompasses 9 structural facets and is based on a sample size of 649, fulfilling the requirements for the latent variable analysis and sample size in SEM. The data analysis was conducted using SPSS 26.0 and AMOS 24.0. This study adhered to the two-step approach proposed by Anderson and Gerbing [76] for evaluating the adequacy of the measurement and structural models.

3.3. Reliability and Validity Analysis

In this study, a confirmatory factor analysis (CFA) was employed to assess the reliability and validity of the research model. In this study, the primary constructs were measured through scales, making the examination of data quality a crucial prerequisite to ensure the significance of subsequent analyses. Initially, the internal consistency of each dimension was analyzed using the Cronbach's alpha coefficient reliability test. The Cronbach's alpha coefficient ranges from 0 to 1, with higher values indicating greater reliability. In this analysis, as shown in Table 4, Cronbach's alpha values for each dimension were greater than 0.7, indicating that the scales used in this study possessed good internal consistency and reliability. In addition, this study also used the composite reliability (CR) coefficient for reliability measurement. According to the results in Table 4, the CR values of all the compositional surfaces were greater than 0.7, which means that the measurement model had high compositional reliability [77].

Table 4. Internal and convergent reliability.

Constructs	Items	Cronbach's Alpha	Factor Loadings	AVE	CR
Governmental actions	C1	0.877	0.782	0.652	0.849
	C2		0.832		
	C3		0.805		
Pressure from other stakeholders	D1	0.88	0.771	0.627	0.870
	D2		0.826		
	D3		0.764		
	D4		0.798		
Knowledge accumulation	F1	0.848	0.805	0.618	0.89
	F2		0.778		
	F3		0.784		
	F4		0.765		
	F5		0.797		
Structure overlap	G1	0.87	0.805	0.625	0.870
	G2		0.797		
	G3		0.774		
	G4		0.788		
Resource endowments	H1	0.89	0.844	0.662	0.907
	H2		0.797		
	H3		0.785		
	H4		0.782		
	H5		0.858		
Dynamic capability	Q1	0.87	0.811	0.622	0.868
	Q2		0.748		
	Q3		0.793		
	Q4		0.802		
Environmental awareness	A1	0.907	0.748	0.588	0.877
	A2		0.748		
	A3		0.766		
	A4		0.777		
	A5		0.758		
Economic value estimation	B1	0.868	0.84	0.710	0.880
	B2		0.82		
	B3		0.866		
The transition to RESs	Y1	0.929	0.844	0.687	0.929
	Y2		0.834		
	Y3		0.79		
	Y4		0.826		
	Y5		0.833		
	Y6		0.825		

Validity includes convergent validity and discriminant validity. Average variance extracted (AVE) reflects the mean of the explanatory power of the latent variables for the observed variables. As can be seen from the results in Table 4, the AVE values of all the constructs were greater than 0.5, which meets the criteria suggested by Fornell and Larcker [78], indicating that the constructs had good convergent validity. In this discriminant validity test (Table 5), the standardized correlation coefficients between each pair of dimensions were all less than the square root of the AVE value corresponding to the dimension, thus demonstrating that all the dimensions had good discriminant validity.

Table 5. Discriminant validity.

Variable	Governmental Actions	Pressure from Other Stakeholders	Knowledge Accumulation	Structure Overlap	Resource Endowments	Dynamic Capability
Governmental actions	0.652					
Pressure from other stakeholders	0.149	0.627				
Knowledge accumulation	0.187	0.309	0.618			
Structure overlap	0.184	0.213	0.304	0.625		
Resource endowments	0.147	0.080	0.118	0.108	0.662	
Dynamic capability	0.091	0.137	0.196	0.156	0.223	0.622
Environmental awareness	0.382	0.494	0.367	0.406	0.101	0.200
Economic value estimation	0.325	0.400	0.374	0.406	0.036	0.088
The transition to RESs	0.279	0.339	0.375	0.438	−0.152	0.162
The square root of AVE.	0.808	0.792	0.786	0.791	0.814	0.789

3.4. CFA Model Fit Test

According to the model fit assessment results presented in Table 6, the Chi-square to degrees of freedom ratio (Chi-square/d.f.) was 1.209, which falls within the acceptable range of 1–3. The Root Mean Square Error of Approximation (RMSEA) was 0.018, indicating an excellent fit as it was less than 0.05. Additionally, the results for the Incremental Fit Index (IFI), Tucker–Lewis Index (TLI), Comparative Fit Index (CFI), Normed Fit Index (NFI), and Adjusted Goodness of Fit Index (AGFI) all exceeded the threshold of 0.9. Considering these indices collectively, we can conclude that the model fit indices met the measurement standards recommended by previous research.

Table 6. The fit indices.

Fit Indices	Recommendations	Measured Results
Chi-square/d.f.	1–3 for excellent, 3–5 for good	1.209
RMSEA	<0.05 for excellent, <0.08 for good	0.018
IFI	>0.9 for excellent, >0.8 for good	0.991
TLI	>0.9 for excellent, >0.8 for good	0.989
CFI	>0.9 for excellent, >0.8 for good	0.990
NFI	>0.9 for excellent, >0.8 for good	0.948
AGFI	>0.9 for excellent, >0.8 for good	0.932

4. Results and Discussion

4.1. Structural Results

The structural results are presented in Table 7 and Figure 2. The results indicate that all 13 hypotheses were supported, and 1 hypothesis was rejected, relating to pressure from other stakeholders and the transition to RESs ($H8, \beta = 0.082, CR = 1.738, p > 0.05$). Specifically, the transition to RESs of O&G companies was significantly motivated by governmental actions, pressure from other stakeholders, knowledge accumulation, structure overlap, environmental awareness, and economic value estimation ($H7, \beta = 0.104, CR = 2.437, p < 0.05$; $H9, \beta = 0.146, CR = 3.594, p < 0.001$; $H10, \beta = 0.234, CR = 5.658, p < 0.001$; $H12, \beta = 0.089, CR = 2.369, p < 0.05$; $H13, \beta = 0.148, CR = 3.139, p < 0.01$; $H14, \beta = 0.213, CR = 4.653, p < 0.001$) but was significantly negatively affected by resource endowments ($H11, \beta = -0.261, CR = -7.053, p < 0.001$). Environmental awareness was significantly affected by two determinants, governmental actions and pressure from other stakeholders, with the effect of the pressure from other stakeholders ($H2, \beta = 0.461, CR = 10.365, p < 0.001$) being more powerful than that of governmental actions ($H1, \beta = 0.325, CR = 7.709, p < 0.001$). Economic value estimation was significantly related to four factors, governmental actions ($H3, \beta = 0.209, CR = 5.089, p < 0.001$), pressure from other stakeholders ($H4, \beta = 0.265, CR = 6.189, p < 0.001$), knowledge accumula-

tion (H5, $\beta = 0.17$, $CR = 3.969$, $p < 0.001$), and structure overlap (H6, $\beta = 0.25$, $CR = 5.861$, $p < 0.001$). However, there were no significant direct relationships between pressure from other stakeholders and the transition to RESs (H8, $\beta = 0.082$, $CR = 1.738$, $p > 0.05$).

Table 7. Structural results.

	Hypothesis		Standard Path Coefficient	S.E.	C.R	Supported
H1. Environmental awareness	←	Governmental actions	0.325 ***	0.035	7.709	supported
H2. Environmental awareness	←	Pressure from other stakeholders	0.461 ***	0.04	10.365	supported
H3. Economic value estimation	←	Governmental actions	0.209 ***	0.043	5.089	supported
H4. Economic value estimation	←	Pressure from other stakeholders	0.265 ***	0.049	6.189	supported
H5. Economic value estimation	←	Knowledge accumulation	0.17 ***	0.044	3.969	supported
H6. Economic value estimation	←	Structure overlap	0.25 ***	0.042	5.861	supported
H7. the transition to RESs	←	Governmental actions	0.104 *	0.049	2.437	supported
H8. the transition to RESs	←	Pressure from other stakeholders	0.082	0.059	1.738	Not supported
H9. the transition to RESs	←	Knowledge accumulation	0.146 ***	0.045	3.594	supported
H10. the transition to RESs	←	Structure overlap	0.234 ***	0.044	5.658	supported
H11. the transition to RESs	←	Resource endowments	−0.261 ***	0.037	−7.053	Supported
H12. the transition to RESs	←	Dynamic capability	0.089 *	0.043	2.369	supported
H13. the transition to RESs	←	Environmental awareness	0.148 **	0.065	3.139	supported
H14. the transition to RESs	←	Economic value estimation	0.213 ***	0.049	4.653	supported

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

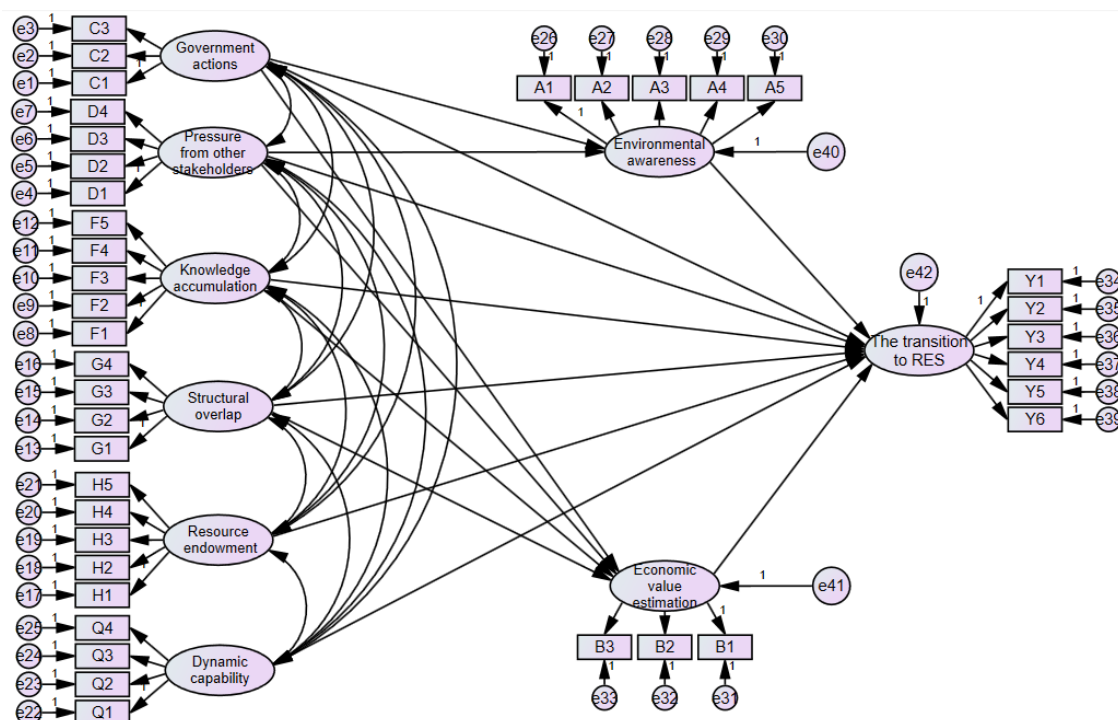


Figure 2. Estimation of the theoretical model of the mechanism of O&G companies' transition to renewable energy.

4.2. Multi-Group Model Test

Intentions do not always translate into actions, and discrepancies between intentions and behaviors are often observed in reality. Numerous studies have found that while some O&G companies express support for climate change science and policies in their political discourse, their economic behaviors, such as actual investments in RESs and the transformation of business models, are relatively limited. Therefore, the study of O&G companies' transition behavior towards RESs cannot overlook the differences in transition intentions. To this end, this section incorporates the transition intentions of O&G companies towards RESs as an important moderating variable into the structural equation model constructed in the previous text, to examine its impact on the transition behavior of O&G companies towards RESs. Specifically, we further assessed and standardized the sample companies' development strategies, investment plans, leadership statements, and other relevant behaviors regarding RESs, considering companies with scores above the average as the high-intention group and those below the average as the low-intention group, to investigate whether there are significant differences in the impact of internal and external driving factors on the transition behavior of O&G companies towards RESs between these two different groups. The research results will reveal how transition intentions act as a moderating factor, regulating the implementation of actions by O&G companies in the field of RESs, thereby providing a deeper understanding of the energy transition in the O&G industry.

In conducting the multi-group model fit test, this study compared the fit of five models: the preset model, the covariance equality model, the variance equality model, the path coefficient equality model, and the model invariance model. Through this comparative analysis, the measurement weights model was ultimately selected for the multi-group analysis. The CMIN/DF was 1.197, which is below the excellent standard of 3, and the values of the NFI, IFI, TLI, and CFI were all within the acceptable range, with the RMSEA being less than 0.08 (specific values are provided in Appendix A, Table A1), indicating that the model had good stability.

Building on the multi-group model fit test, this study further employed a multi-group structural equation modeling analysis to conduct cross-group invariance testing for the two groups. The test results in Appendix A, Table A2, show that the changes in the NFI, RFI, IFI, and TLI values were all within a range of 0.05, suggesting that there were significant differences in the paths among groups with different willingness levels. These indicators suggest that the multi-group analysis model fit the sample data well. Therefore, the next step focused on comparing the differential impacts of the pathways between variables in the high transformation willingness group and the low transformation willingness group.

In this study, the differences in the path coefficients between the high transformation intention group and the low transformation intention group are presented in Table 8. The result shows that some of the hypotheses proposed in this paper, namely H3, H4, H5, H6, H8, H9, H10, H12, H13, and H14, did not show significant differences between the two groups, while H1, H2, H7, and H11 exhibited significant differences. Specifically, the impact of government actions and pressure from other stakeholders on corporate environmental awareness varied depending on the company's transformation intention. For O&G companies with high transformation intentions, the impacts of government actions ($\beta = 0.393$) and pressure from other stakeholders ($\beta = 0.501$) on environmental awareness were significantly greater than for companies with low transformation intentions. In terms of promoting the transition of O&G companies to RESs, the effects of government actions (H7) and resource endowments (H11) differed between groups with different transition intentions. Government actions had a significantly positive impact on the transition behavior of O&G companies with high transformation intentions, while their impact on the low intention group was not significant. Resource endowments significantly influenced the transition of both groups, but their impact on companies with low transformation intentions was more pronounced. In contrast, the influence of pressure from other stakeholders (H8), knowledge accumulation (H9), dynamic capabilities (H12), structural overlap

(H10), and economic value estimation (H14) on the participation of O&G companies in energy transition did not show significant differences due to different transition intentions. Regarding the impact on the economic value estimation of renewable energy by O&G companies, government actions significantly affected companies with high transformation intentions, while their impact on companies with low transformation intentions was not significant. The influence of pressure from other stakeholders, knowledge accumulation, and structural overlap on the economic value estimation of renewable energy by O&G companies did not show significant differences due to different transition intentions.

Table 8. Comparison of path coefficients of different transition intention groups.

H	Path		Willing Group		Unwilling Group		Critical Value	Difference Result
			Estimate	S.E.	Estimate	S.E.		
H1	Environmental awareness	← Governmental actions	0.393 ***	0.039	0.169 *	0.071	−2.653	Yes
H2	Environmental awareness	← Pressure from other stakeholders	0.501 ***	0.05	0.388 ***	0.073	−2.312	Yes
H3	Economic value estimation	← Governmental actions	0.204 ***	0.05	0.215 **	0.085	0.027	No
H4	Economic value estimation	← Pressure from other stakeholders	0.285 ***	0.061	0.239 **	0.088	−1.137	No
H5	Economic value estimation	← Knowledge accumulation	0.143 **	0.053	0.234 **	0.082	0.713	No
H6	Economic value estimation	← Structure overlap	0.261 ***	0.054	0.222 **	0.073	−0.536	No
H7	the transition to RESs	← Governmental actions	0.175 **	0.05	−0.041	0.074	−2.38	Yes
H8	the transition to RESs	← Pressure from other stakeholders	−0.013	0.064	−0.057	0.083	−0.415	No
H9	the transition to RESs	← Knowledge accumulation	0.119 **	0.044	0.168 *	0.07	0.556	No
H10	the transition to RESs	← Structure overlap	0.173 ***	0.045	0.19 **	0.063	0.436	No
H11	the transition to RESs	← Resource endowments	−0.373 ***	0.038	−0.506 ***	0.064	−2.435	Yes
H12	the transition to RESs	← Dynamic capability	0.006	0.046	−0.039	0.061	−0.547	No
H13	the transition to RESs	← Environmental awareness	0.255 ***	0.072	0.243 ***	0.088	0.163	No
H14	the transition to RESs	← Economic value estimation	0.27 ***	0.048	0.246 **	0.077	0.087	No

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

5. Discussion

Reducing global carbon emissions is a critical macro goal that must be translated into tangible corporate actions. Achieving global climate targets and facilitating energy transitions hinge on the proactive adjustments and contributions of individual companies [79]. While scholars have started to examine the green transformation of oil and gas firms, comprehensive assessments of the factors driving these companies' shift to renewable energy, particularly in China, are scarce. Practically, oil and gas companies must integrate resources and knowledge, both internally and externally, to expedite innovation and technological advancements, thereby hastening their green transformation. Our study, after extensive research, categorizes the influencing factors into eight categories, including government actions, pressure from other stakeholders, resource endowment, dynamic capability, knowledge accumulation, structural overlap, environmental awareness, and economic value estimation. We developed a theoretical model to investigate the drivers behind the renewable energy transition in oil and gas companies. Using structural equation modeling, we empirically tested this model and included transformation intention as a moderating variable. The goal was to bridge the gap in current research by examining both the impact of the energy transition and the moderating role of transformation willingness on corporate sustainability efforts.

The transition to RESs in China has been both directly and indirectly influenced by government actions. This highlights the multifaceted role of the government in the green transformation of oil and gas companies. As a regulator, the government guides corporate behavior through the establishment and enforcement of stringent environmental protection regulations. It also acts as a facilitator, encouraging investment in renewable energy through tax incentives, subsidies, and other motivational measures. Moreover, as a driver, the government propels the transformation of the energy structure through proactive policy guidance and the creation of effective market mechanisms. These roles

are crucial in accelerating the shift towards a sustainable energy future, ensuring that the transition is not only environmentally responsible but also economically viable.

An unexpected finding was that pressure from other stakeholders does not directly drive the transition to renewable energy sources (RESs); instead, it indirectly exerts influence by shaping the oil and gas companies' environmental awareness and economic value estimation. This suggests that the pressure conveyed by other stakeholders may take time to manifest its effects, as it is likely associated with long-term strategic planning and reputation management rather than prompting immediate changes in action. This study confirms that environmental awareness plays a significant role in promoting sustainable business practices. It is crucial to value and understand corporate environmental consciousness, as it can assist organizational theorists in predicting behaviors based on environmental protection. For example, if oil and gas companies adopt strategies to transition to renewable energy solely to meet legislative requirements, they may only implement the minimum necessary changes to adhere to the law, rather than actively pursuing broader sustainable solutions. Furthermore, this understanding can nurture mechanisms for environmentally sustainable organizations, allowing researchers, managers, and policymakers to assess the relative effectiveness of command-and-control mechanisms, market measures, and voluntary initiatives. This, in turn, can more effectively encourage enterprises to undertake deeper environmental actions, propelling the entire industry towards a greener and more sustainable trajectory [35].

In our multi-group analysis, we found that for oil and gas companies with a high intention to transition, the influence of government actions and pressure from other stakeholders on their environmental awareness is particularly significant. This is likely because companies with a strong intention to transition are generally more attuned to changes in the market and policy and are more willing to take proactive steps to respond to these external pressures, thus maintaining their market competitiveness and brand image. Government policies and regulations, along with pressures from stakeholders, such as investors, consumers, and environmental organizations, can be powerful motivators for these companies to strengthen their environmental protection initiatives. Despite the resource endowment having a significantly negative effect on the transition of oil and gas companies to renewable energy in both groups, this impact is more pronounced among those with a low intention to transition. This indicates that companies with less intention to transition may be hindered in their ability to pursue a transformation path due to their heavy dependence on traditional oil and gas resources, which can impede industry diversification and sustainable economic growth. These companies may lack the necessary technology, capital, or market mechanisms to facilitate the transition, or they may be hesitant to make the necessary investments and changes due to uncertainties in the market and policy environment. If oil and gas companies rely too heavily on traditional oil and gas resources, they may fall behind in the general trend towards low-carbon transition, missing out on opportunities to develop new energy sources and low-carbon technologies. This also implies that to enhance the environmental awareness and actions of these companies, more external incentives and support may be required to promote their transformation.

6. Conclusions

This study explored the determinants of transition to RESs behavior in O&G companies by proposing and validating a research model. The findings indicate that environmental awareness, economic value estimation, knowledge accumulation, governmental actions, structural overlap, resource endowment, and the dynamic capabilities of O&G companies are significant factors influencing their RES transition behaviors. The high fit indices of the model and the validation of the proposed hypotheses confirm the robustness of the research model.

The research also elucidates the structural connections between governmental actions, pressure from other stakeholders, and environmental awareness, as well as the interrelationships among governmental actions, pressures from other stakeholders, knowledge

accumulation, structural overlap, and economic value estimation. The high fit indices of the model and the validation of the proposed hypotheses confirm the robustness of the research model.

Furthermore, the multi-group analysis reveals partial differences in the aforementioned pathways among different transformation willingness groups, indicating that the transformation willingness of O&G companies has a moderating effect on their actual transformation behavior and its influencing mechanisms to some extent. This further underscores the importance of considering the differences in transformation willingness when discussing the behavior of O&G companies in transitioning towards RESs. This study's results contribute to a deeper understanding of the motivations and barriers for traditional energy enterprises in energy transition, which is of significant importance for mitigating global climate change and achieving high-quality economic development in the new era. Based on the aforementioned findings, to better leverage the positive role of O&G companies in energy transition and achieve green development, the following policy recommendations are proposed.

Firstly, governments should align with the global trend of energy system transformation by accelerating the construction of new types of infrastructure, such as smart grids, efficient energy storage systems, and extensive charging networks. The development of these infrastructures will provide a solid external environment and the necessary technical support for the energy transition of O&G companies, thereby speeding up their shift towards green and low-carbon energy sources. Furthermore, governments can establish a sustainable research and development (R&D) and innovation system based on RESs. Through this system, companies will not only make substantial progress in environmental governance and green development but also harness the potential of renewable energy to achieve fundamental transformations in their business models and operational methods. Additionally, governments should guide and incentivize companies to increase their R&D investments in renewable energy technologies, energy efficiency improvements, and the application of clean energy. This will help companies to develop new business opportunities and enhance their competitiveness in the global energy market.

Secondly, O&G companies must actively cultivate a new energy consciousness. This involves enhancing employees' understanding of the importance of RESs, strengthening their professional skills in this field, and providing further education and training for existing professionals to ensure that RES technologies can be integrated into the company's daily operations, management, and production processes. When assessing the value of transitioning to RESs, companies should not only consider the direct economic benefits of transformation from the perspective of cost reduction and efficiency improvement but also conduct a comprehensive evaluation of the full financial and strategic benefits that energy transition can bring to the enterprise in terms of enhancing efficiency, reducing costs, promoting innovation and R&D, and improving environmental governance.

Lastly, O&G companies should fully capitalize on their comparative advantages in the development of RESs, such as their structural overlap and accumulated knowledge. For example, they can explore the repurposing of existing infrastructure, such as pipelines and storage facilities, for the transportation and storage of renewable energy. Additionally, by enhancing technology transfer and innovation, the advanced technologies and knowledge that O&G companies possess in relation to exploration, extraction, and production can be applied to the renewable energy sector, particularly in the development of offshore wind and geothermal energy. When confronting the negative impact of resource endowments on the transition to renewable energy, O&G companies must take proactive measures to overcome the resource lock-in effect. This can be done by intensifying R&D in renewable energy technologies, optimizing resource allocation, and increasing organizational flexibility, all of which contribute to the company's sustainable development. Furthermore, O&G companies can also leverage their influence in the policy-making process to advocate for policies that support the development of renewable energy and participate in the formulation and

implementation of such policies. This not only aligns with their strategic interests but also aids in achieving broader objectives of energy transition and environmental sustainability.

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Appendix A

Table A1. Fit Evaluation results for measurement weight models.

Statistical Test	Criterion or Critical Value	Data	Model Fit Judgment
RMR	<0.05	0.004	Yes
Chi-Square/DF Ratio	<3	1.197	Yes
RMSEA	<0.08	0.017	Yes
GFI	>0.7	0.89	Yes
AGFI	>0.7	0.875	Yes
NFI	>0.7	0.892	Yes
CFI	>0.7	0.98	Yes

Table A2. Cross-group invariance testing results.

Model	DF	CMIN	NFI	IFI	RFI	TLI
			Delta-1	Delta-2	rho-1	rho2
Measurement weights	30	29.296	0.002	0.002	0	−0.001
Structural weights	44	59.349	0.004	0.004	0	0.001
Structural covariances	65	125.297	0.008	0.009	0.003	0.004
Structural residuals	68	149.459	0.01	0.011	0.005	0.005

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