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The mediating role of energy efficiency on the relationship between sharing economy benefits and sustainable development goals (Case Of China)

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ABSTRACT

Recently, sustainable development goals (SDGs) have become a global requirement, but a changing phenomenon which needs to be examined frequently and which is the focus of recent literature and regulation. Thus, the present study examines the impact of sharing economy benefits such as reasonable use of energy resources, enhanced energy resource efficiency, and reduced energy cost, based on the SDGs of the manufacturing industry in China. The study explores the role of improved energy efficiency as a mediator in the nexus of the reasonable use of energy resources, enhanced energy resource efficiency, reduced energy costs, and SDGs. The article uses the primary data collection method of questionnaires to collect data from selected respondents, the managers of the manufacturing companies. The study employs Smart-PLS to check the reliability of the items and evaluate whether the variables are associated. The results reveal that reasonable use of energy resources, enhanced energy resource efficiency, and reduced energy costs have positive links with SDGs in the manufacturing industry in China. The results show improved energy efficiency to be among the linkages of the reasonable use of energy resources, enhanced energy resource efficiency, reduced energy costs, and SDGs of the manufacturing industry in China. This study can help economists, environmental regulators, and commissions for sustainable development in designing policies to encourage the sharing economy within countries and achieve SDGs.

Introduction

The business world is seeing rapid changes, making the globe a global village and closing the distance between countries. This global transformation is having a direct impact on the economy of every country, as each tries to maximize the utility of their resources. Countries focus on using their resources or assets to attain sustainable development in the economy. Two factors are connected to this concept: (1) the achievement of sustainable development goals (SDGs); and (2) maximum utilization of country resources. This is the case for all sectors of the economy such as manufacturing, industrial, energy, etc. Various SDGs have been achieved in recent times through the current economic model of the sharing economy (SE), which is a collaborative economic concept that helps communities share resources and reduces costs while also reducing negative environmental and cultural repercussions. Sustainable development is discussed in various ways by various authors (Ainou, Ali & Sadiq, 2022; Muñoz & Cohen, 2017; Ritter & Schanz, 2019; Wei, Wu, Guo & Wei, 2021; Xueying, Sadiq, Chien, Ngo & Nguyen, 2021). The definition of sustainable development, as given by the World Commission on Environment and Development (WCED), is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Kamaruddin, Anwar, Chien & Sadiq, 2021; Ritter & Schanz, 2019; Zhao, Zhang, Sadiq, Hieu & Ngo, 2021). The Millennium Declaration, which defines economic growth, social development, and environmental preservation, also sees sustainable development in this way (Apotoaie & Bilan, 2020; Curtis & Lehner, 2019; Xiang et al., 2021). Current changes in the way we see sustainable development emphasize the circular or shared use of resources (Geissinger, Laurell, Öberg & Sandström, 2019; Lan, Khan, Sadiq, Chien & Baloch, 2022) and the social components at the political and cultural level (Frenken, 2017; Liu, Yin, Surya Putra & Sadiq, 2022; Sadiq et al., 2021a). Literature proposes that there are three main elements of sustainable development: development (socioeconomic development), needs (resource redistribution for better quality of life), and future generations (use of resources in the long run to ensure the quality of life of future generations) (Cheba, Bąk & Szopik-Depczyńska, 2020; Muñoz & Cohen, 2017; Sadiq, Hsu, Zhang & Chien, 2021b).

China is the world's largest industrial nation, but not yet as strong as it should be. Manufacturing is one of the most prominent and fastest-growing industries, accounting for a significant proportion of the

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country's gross domestic product (GDP) (Lan, Chen, Li, Guo & Huang, 2021; Sadiq et al., 2021c; diSmriti & Das, 2018). China's manufacturing industry experiences many internal and external constraints in the worldwide market, including a lack of creative input, poor energy efficiency, significant environmental pollution, growing labor prices, and cheaper production costs in other emerging manufacturing nations. The Chinese State Council's "Made in China 2025″ strategy intends to shift the manufacturing industry's pattern of development away from relying mainly on natural physical resources and toward environmental conservation (Jin, Shang & Xu, 2018; Sadiq, Amayri & Paramaiah, 2022a; Tan et al., 2021; Xu & Wang, 2018). There was a 1.6% year-over-year reduction in the first half of 2020, despite some equipment industries having rapid growths in output, such as excavators and shoveling machines, integrated circuits, industrial robots, and vehicles which had 16.7%, 16.4%, 10.3%, and 8.4% growth, respectively. It was estimated that China's manufacturing production would decrease by 3.5% (negative) in the year 2020, before rebounding to a 5% growth rate in 2021. This was significantly more positive than previous projections, which expected a 4.0% decrease in 2020. Manufacturing of computers, allied communication and other electric equipment stood at 5.7%, manufacturing of special machinery stood at 2.9%, manufacturing of medicine stood at 1.8%, and manufacturing of non-ferrous materials stood at 1.8%, the only four major industries to see positive growth in the first half of 2020 (1.0%) (Bilan, Hussain, Haseeb & Kot, 2020; Huo & Chaudhry, 2021; Othman, Nordin & Sadiq, 2020; Shen & Lin, 2020). China's industrial production dropped by 3.4% in 2020, to $16.3 trillion. The production of machinery was predicted to fall by as much as 4.1%, resulting in a market value loss of $34.6 billion. Automotive output saw the biggest impact, with a dip of 13.0% and a loss of nearly $170 billion. Machine tools were the most affected equipment sector, with a negative growth rate of 20.4%. From 2019 to 2020, revenue dropped from $64.2 billion to $51.1 billion. China's manufacturing industry output was expected to reach 2019 levels by 2021, at $18.3 trillion, and reach $20.0 trillion by 2024, with a compound growth rate of 2.3% (from 2019 to 2024) (Chien, Zhang, Sadiq & Hsu, 2021c; Fan, You, zhang & Zhou, 2021; Moslehpour, Chang, Pham & Dadvari, 2022a; Sadiq et al., 2022b; Vveinhardt & Sroka, 2021). The industry's contribution (inclusive of manufacturing) is given in Fig. 1, which shows a decreasing trend in the industry's contribution to GDP. This trend is one factor in the selection of this industry for the present study.

The current study examines three major factors of sharing economies: energy efficiency (reasonable use of energy resources), enhanced energy resource efficiency, and reduced energy costs in the achievement of SDGs. The achievement of SDGs is a global requirement which is always changing and needs to be examined frequently, showing the study's importance to the literature. This study contributes to the sharing economy literature by adding three factors: reasonable use of energy resources, enhanced energy resource efficiency, and reduced energy costs. The study considers improved efficiency as a mediator, making a significant contribution to the literature. The study addresses several existing literature gaps: (1) although the sharing economy and sustainable development are important topics, research is still lacking; (2) Jelinkova, Tetrevova, Vavra and Munzarova (2021) investigate the nexus of sustainable development, whereas the present study also tests the relationship between the sharing economy and sustainable development by adding: (a) a mediation factor, improved energy efficiency; (b) sharing economy factors such as reasonable use of energy resources, enhanced energy resource efficiency, and reduced energy cost, and (c) a Chinese perspective; (3) Karobliene and Pilinkiene (2021) test the sharing economy and sustainable development in the context of European Union countries while this study tests the model from a Chinese perspective, adding a mediation effect; (4) Govindan, Shankar and Kannan (2020) test sustainable goal achievement through the sharing economy from an Indian perspective while this study adds a mediation effect and selects the Chinese manufacturing sector; and lastly, (5) form a Chinese perspective, there is less evidence of relationships with mediation effects.

The significance of the study is: (1) the importance of the sharing economy to achieving SDGs is highlighted; (2) it can help professionals revamp their policies for the best utilization of resources for the achievement of goals set by their organization; and (3) it helps researchers identify the sharing economy concept and its importance for economies and businesses. The study is organized in five phases. The first is introductory, providing an overview of the topic and discussing the gaps in the literature. The second discusses the synthesized literature where the variables are scrutinized in light of the preceding literature. The methodology section, the third phase, provides details of the tools and techniques, population, and research design. The next phase discusses the findings and compares and contrasts the findings with the empirical evidence in the previous literature. Finally, the paper concludes with implications and future recommendations.

Literature review

The sharing economy is a phenomenon that supports sustainable economic activity. It is a combination of information technology and management methods to develop a new culture in which resources are used more efficiently. It provides an innovative framework to pave the way for long-term economic development and energy efficiency. Based on resource efficiency and strong social links, the sharing economy offers a route to long-term development, strengthens non-profit links and has an empowering influence on communities (Ciulli & Kolk, 2019; Moslehpour, Al-Fadly & Ehsanullah, 2022b). As noted in the literature, the emergence of the sharing economy has been received with enormous enthusiasm, owing to its potential to improve outcomes and lead to a more equitable and sustainable

Fig. 1. Industry contribution to Chinese GDP.

economy. It has changed the old way of doing things, resulting in a new phenomenon of sharing and transacting in digital spaces. The potential benefits include more efficient resource use, which leads to less overproduction and resource exploitation (Acquier, Daudigeos & Pinkse, 2017; Moslehpour, Ismail, Purba & Wong, 2021).

Energy is one of society's basic needs, and demand is increasing over time. The world is investing its prime effort into exploring new ways of producing energy and paying increasing attention to renewable energy. Both non-renewable and renewable energy resources play a vital role in SDGs. In this context, Chien et al. (2021b) and Fuso-Nerini et al. (2018) investigate the trade-off between energy and development goals. There are 113 targets which require steps to change the energy system. There is an urgent need to connect all the actors involved to achieve SDGs. In view of the Paris Agreement, McCollum et al. (2018) investigate the need for energy investment to achieve SDGs. Low-carbon energy investment is necessary to achieve the SDGs of the Paris Agreement. The world's increasing economic activity, population expansion, and rising living standards result in a continual increase in the need for both the quality and quantity of energy services. As the economy grows, so does the need for power, posing new issues in terms of generation and putting a strain on utility infrastructure. The world is seeking an acceptable energy model that allows for the integration of locally accessible renewable energy sources such as solar, wind, biomass, small hydro, and others into the existing grid, while decreasing energy infrastructure investment. In this context, Wagh and Kulkarni (2018) reveal that renewable energy resources are the best alternative to conventional fuels. Energy experts plan for the maximum penetration of resources into the grid as energy is a significant enabler of SDGs as well as playing a critical role in the reduction of poverty and hunger, providing healthcare, education and water, supporting economic growth, and safeguarding the environment. Because SDGs can only be implemented at the local or national level, including SDGs in local and national development planning puts a strain on a country's energy sector. By taking a broader perspective of SDGs, countries can prioritize objectives based on their requirements, resources, and capabilities. Energy's relationship with SDGs is complex, with direct and indirect connections, synergies, and trade-offs. Santika et al. (2019) test the relationship between sustainable development and energy. Boar, Bastida and Marimon (2020) investigate the benefits of the sharing economy relating to reasonable energy use and the achievement of company SDGs. The results are helpful for energy policymakers forecasting energy demand. Hence the first hypothesis of this study:

H1. The **s**haring economy benefit of reasonable use of energy resources, has a significant and positive association with SDG achievement.

Efficient energy use, known as energy efficiency, uses less energy to achieve the same amount of service. According to the International Energy Agency, energy-efficient buildings, industrial processes, and transportation may cut the world's energy demand by one-third by 2050, while helping to limit global greenhouse gas emissions. The twin bases of the sustainable energy strategy are energy efficiency and renewable energy. Energy efficiency is a cost-effective technique for improving economics without increasing energy use. One core need of technology is maximum output within minimal time. Matuszewska-Pierzynka (2021) and Østergaard, Duic, Noorollahi, Mikulcic and Kalogirou (2020) investigate the nexus between sustainable development and renewable energy technology. This study provides an overview of the current research into renewable energy exploitation, emphasizing the state of renewable energy technologies, renewable energy availability assessments, and research into the sorts of systems that may incorporate renewable energy sources. Energy conversion efficiency is the ratio of an energy conversion machine's usable output to its input. Electrical power, mechanical work, or heat can all be beneficial outputs. The energy output is always less than the energy intake. Efficient usage of resources is a point of concern for building contractors as they need to enhance the energy efficiency of heating systems. Klymchuk, Denysova, Balasanian, Ivanova and Bodiul (2020) and Chien, Hsu, Ozturk, Sharif and Sadiq (2022) test how to enhance the efficiency of energy resource usage by applying variable operation modes. The findings apply to heat supply systems in buildings that operate in a two-period model (operation duty) and employ traditional and renewable heat sources. This can improve the efficiency of heat supply system elements, smooth out the daily heat-generating schedule, and extend the service life of equipment. Energy is the driving force of life on earth, and therefore its availability and usage are critical for all economic activity. Energy is a critical component of economic growth and prosperity. Worldwide energy consumption in 2017 was 14,050 million tons of oil (Mtoe), an increase from 10,035 Mtoe in 2000. Ohene-Asare, Tetteh and Asuah (2020) test the relationship between energy efficiency and economic development in 46 African countries within a three stage framework. Economic development and technological advancement are demonstrated to have considerable benefits for African nations' energy efficiency, but increasing energy prices lead to increased inefficiency. A bi-causal link is evident between total factor energy efficiency and economic development (Aslam, Saleem, Khan & Kim, 2021; Chien et al., 2021a; Liu et al., 2021a; Mills, 2017; Pan, Chen, Ying & Zhang, 2020), bolstering the idea of sustainable development and verifying the International Energy Agency's declaration on energy efficiency's favourable macroeconomic effects. As a result, African nations have been urged to engage in energy efficiency technology and regulation to achieve long-term economic development. Shereni (2019) also suggests that the sharing economy guides the efficient use of energy which helps achieve organizational SDGs. Thus, the current study develops the second hypothesis:

H2. The sharing economy benefit of enhanced energy resource efficiency has a significant and positive association with SDG achievement.

Another factor considered important in an energy efficiency context is cost. The cost of energy plays a vital role in attaining the goals set by any firm or country. The use of renewable resources also reduces energy costs. Globalization is an international phenomenon with a social and political influence on human lives (Bekun, Yalçiner, Etokakpan & Alola, 2020; Heinrich, Blaauw & Pretorius, 2020), and more beneficial impacts than negative consequences, especially in terms of poverty and income disparity reduction in developing economies. China is quickly becoming a modern source of economic cooperation and globalization, owing to new corporate growth and the world economy turning its attention towards it. The lower energy costs are, the better the chances of sustainable development. Therefore, the cost of energy is a key element in the success of any project. Ehsanullah et al. (2021) and Schwerhoff and Sy (2017) investigate renewable energy financing in the African context. Given the difficulty of providing development to a fast-rising population, Africa may be tempted to follow a policy of fuelling its expansion with the cheapest sources of energy available and addressing environmental concerns only afterwards. However, such an approach ignores the societal costs of fossil fuels, which the general public would have to bear. We identify synergistic benefits of renewable energy, using SDGs as a standard for equitable and sustainable progress. Significant initiatives to finance the increased cost of renewable energy are already underway. An examination of the potential leverage points, accessible tools, and participating players reveals a significant amount of untapped potential. Hence, there is a positive association between energy cost reduction and sustainable development (Gonçalves & Santos, 2019; Flores & Chang, 2020; Huang, Sadiq & Chien, 2021a). Reduction in energy costs is part of energy efficiency, and both enable the achievement of SDGs. Governments worldwide are dedicated to long-term development goals. Energy-efficient buildings may make a substantial contribution to SDGs, as urban agglomerates consume around 80% of global energy, of which buildings account for 40%. Di Foggia (2018) explores the relationship between energy efficiency and SDGs, narrowed down to energy efficiency

measures in buildings. The study proposes that a good energy policy offers consumers trustworthy information and project developers a stable regulatory framework. Investment behavior is logical and sensitive to credible information, prompting a shift toward environmentally friendly building options. To decrease the depletion of natural resources, the drive towards renewable energy has seen the birth of a new business model based on the sharing economy, which facilitates the transformation of the energy system (Dallisa & Govinder, 2020; Huang, Sadiq & Chien, 2021b; Koloba, 2020; Ode & Ayavoo, 2020; Plewnia, 2019). As a result, a new consumption pattern has evolved among strangers, involving the sharing of commodities and services through coordinated purchase and flexible distribution. This results in increased efficiency and a decrease in marginal costs (Kikulwe & Asindu, 2020; Pucheanu, Bugheanu & Dinulescu, 2020). In addition, Olabi et al. (2022) investigate the sharing economy benefits related to the reduction in energy costs that helps achieve company SDGs. Thus, the study develops the third hypothesis:

H3. The sharing economy benefit of reduced energy costs has a significant and positive association with SDG achievement.

Improvements in energy efficiency are a step toward achieving SDGs in firms and industries. More efficient energy use at all levels of the supply and demand cycle might mitigate the negative impact of energy use while allowing for the same economic development. Furthermore, adverse energy use is higher than the necessary running cost for the consumer. Higher energy efficiency lowers operational costs and increases profitability at the entrepreneur level. Improved energy efficiency at the national level implies lower energy imports, which reduces foreign exchange pressure while increasing the availability of scarce energy resources for others, allowing an increase in energy-dependent activities to contribute to the overall economic well-being of the population. Advanced energy efficiency benefits society by reducing the negative environmental implications of energy consumption. Energy efficiency can be improved by multiple means, such as improving energy productivity, implementing an energy management system, and best practice in technology and innovation. The vast disparities in energy production worldwide can be attributed to fundamental processes and structural factors. For example, nations or areas with the highest proportion of electric steel (Europe, the United States, South Korea, Taiwan, and Turkey) have the highest energy productivity. However, China's chemical sector has low energy productivity since the raw material used is coal rather than gas. Inefficient vertical shaft kilns are used in about half of all cement production in China, diminishing the sector's energy productivity. Meanwhile, the paper industry in the United States suffers from the technological age of its production facilities (Liu, Lan, Chien, Sadiq & Nawaz, 2021b; Lu, Xu, Shen, Tian & Shen, 2019). Energy management systems (EnMS) allow for the systematic analysis, management, and reduction of energy consumption. EnMS are gaining traction among industry executives who realize their strategic potential as cost-effective ways to conserve energy, decrease greenhouse gas emissions, improve energy security, and support sustainable development (Huang, Chien & Sadiq, 2021c; Ikram, Zhou, Shah & Liu, 2019; Iris & Lam, 2019; Li et al., 2021). Thus, we develop the further hypotheses:

H4. Improvement in energy efficiency significantly mediates enhanced energy resource efficiency and the achievement of SDGs.

H5. Improvement in energy efficiency significantly mediates reasonable use of energy resources and the achievement of SDGs.

H6. Improvement in energy efficiency significantly mediates reduced energy cost and the achievement of SDGs.

Research methodology

This article examines the impact of reasonable use of energy resources, enhanced energy resource efficiency, and reduced energy costs on SDGs. The mediating effect of improved energy efficiency on the nexus of reasonable use of energy resources, enhanced energy resource efficiency, reduced energy costs, and the SDGs of the manufacturing industry in China are also investigated. The study takes three predictors of reasonable use of energy resources (RUER) from Cheng, Fu and de Vreede (2018), five predictors of enhanced energy resources efficiency (EERE) from Cheng et al. (2018), and four predictors of reduced energy costs (REC) from Sung, Kim and Lee (2018). The mediator instrument (IEEE) is adopted from Tan, Ooi and Goh (2017), and, finally, the

Table 1
Measures of the constructs.

Variable	Item	Statement	Source
Sustainable Development Goals	SDG1	"I am satisfied that sharing economy practices solve environmental issues."	(Noordin & Sulaiman, 2010)
	SDG2	"I am concerned about environmental problems at my workplace."	
	SDG3	"I always discuss environmental problems with my friends."	
	SDG4	"I try to reduce the amount of waste at the workplace by using sharing economy practices."	
	SDG5	"I conserve the use of electrical energy at the workplace."	
	SDG6	"I am aware of my responsibility towards the environment."	
Improve Energy Efficiency	IEE1	"It is important to me whether workplace appliances are energy-efficient."	(Tan et al., 2017)
	IEE2	"Environmental protection is important to me when working in the organization."	
	IEE3	"If I can choose between energy-efficient workplace appliances and non-energy-efficient workplace appliances, I prefer energy-efficient ones."	
	IEE4	"I have a favourable attitude toward purchasing energy-efficient appliances."	
Reasonable Use of Energy Resources	RUER1	"The sharing economy leads to saving organizational resources."	(Cheng et al., 2018)
	RUER2	"I believe that the sharing economy reduces energy use in the organization."	
	RUER3	"The sharing economy is properly implemented in my organization for saving energy."	
Enhanced Energy Resources Efficiency	EERE1	"The sharing economy reduces the wastage of resources."	(Cheng et al., 2018)
	EERE2	"I believe that the sharing economy reduces the wastage of energy resources."	
	EERE3	"My organization is willing to implement the sharing economy to improve energy efficiency."	
	EERE4	"I believe that the employees know enough about the sharing economy to improve energy efficiency."	
	EERE5	"My organization helps the employees learn about the sharing economy to improve energy resource efficiency."	
Reduced Energy Cost	REC1	"I believe that the sharing economy reduces the organization's overall costs."	(Sung et al., 2018)
	REC2	"My organization reduces energy costs using the sharing economy."	
	REC3	"I believe that my organization is concerned about the sharing economy and reducing energy costs."	
	REC4	"I believe that the energy cost reduction in my organization is due to the effective implementation of the sharing economy."	

sustainable development goals (SDG) are taken as the dependent variable, using six items taken from Noordin and Sulaiman (2010). Table 1 shows the variables and measurements.

The study uses the primary data collection method of questionnaires to collect data from selected respondents. Questionnaire is the best method of data collection to examine the behavior of respondents (Mazhar, Anjum, Anwar & Khan, 2021). The respondents chosen are managers of manufacturing companies, selected using simple random sampling. A total of 50 manufacturing companies were selected, and approximately five to ten managers from each organization were approached, amounting to approximately 360 managers, and 525 questionnaires were sent using personal visits and mail. After a few days, 357 valid surveys were received and used for analysis, representing an approximately 68% response rate.

The study employed Smart-PLS to check the reliability of the items and test the associations among the variables. The PLS-SEM analysis provides the best results, even though the researchers use a complex model and large sample size (Hair et al., 2021; Inegbedion et al., 2021). Smart-PLS is the best estimation tool for primary data analysis (Hair, Risher, Sarstedt & Ringle, 2019). and assesses the item reliability using a measurement model assessment (Ammad, Alaloul, Saad & Qureshi, 2021; Dankiewicz, Ostrowska-Dankiewicz & Bulut, 2020). The item reliability is checked using convergent validity measures such as Cronbach's alpha, factor loadings, average variance extracted (AVE), and composite reliability (CR) (Al Mamun, Muniady & Nasir, 2021; Purwanto & Sudargini, 2021; Sharma, 2020). In contrast, the variable reliability is checked using discriminant validity measures such as Fornell Larcker, cross-loadings, and the heterotrait monotrait (HTMT) ratio (Mah, Ali & Zawawi, 2018). The structural model assessment is used to examine the association between variables (Bierwiaczonek, Gawron, Pyka & Suchacka, 2020; Sarstedt et al., 2020), while the direct path test exposes the direct associations among predictors and predictive variables, and the indirect path test exposes the mediation analysis among the constructs (Al-Emran, Mezhuyev & Kamaludin, 2018). Fig. 2 shows the variables in the theoretical model.

Research findings

The results show convergent validity which exposes the associations among the items. The item reliability is checked using convergent validity measures such as Cronbach's alpha, factor loadings, AVE, and CR. The results show alpha and CR values bigger than 0.70, and loadings and AVE values larger than 0.50. These values indicate a high correlation among the items and convergent validity. These values are given in Table 2.

Table 2
Convergent validity.

Construct	Item	Loading	Alpha	CR	AVE
Enhanced Energy Resource Efficiency	EERE1	0.884	0.908	0.932	0.732
	EERE2	0.900			
	EERE3	0.888			
	EERE4	0.755			
	EERE5	0.842			
Improve Energy Efficiency	IEE1	0.907	0.832	0.890	0.671
	IEE2	0.802			
	IEE3	0.692			
	IEE4	0.860			
Reduced Energy Costs	REC1	0.859	0.925	0.947	0.818
	REC2	0.956			
	REC3	0.864			
	REC4	0.935			
Reasonable Use of Energy Resources	RUER1	0.950	0.892	0.934	0.825
	RUER2	0.837			
	RUER3	0.934			
Sustainable Development Goals	SDG1	0.682	0.885	0.913	0.639
	SDG2	0.727			
	SDG3	0.803			
	SDG4	0.886			
	SDG5	0.850			
	SDG6	0.829			

The results show discriminant validity which exposes the association among the variables. The variable reliability is checked using discriminant validity measures such as Fornell Larcker, cross-loadings, and the HTMT ratio. Fornell Larcker shows that the first value in the column, the association with the variable itself, is greater than the other values, correlation with other variables. Moreover, the values show that the discriminant validity is acceptable as it satisfies the benchmark These values are given in Table 3.

The cross-loading results indicate that the values that show association with the variable are larger than other values that show association with other variables. Therefore, the correlation among the variables is low, which is a good sign, and also the values of validity are acceptable. These values are given in Table 4.

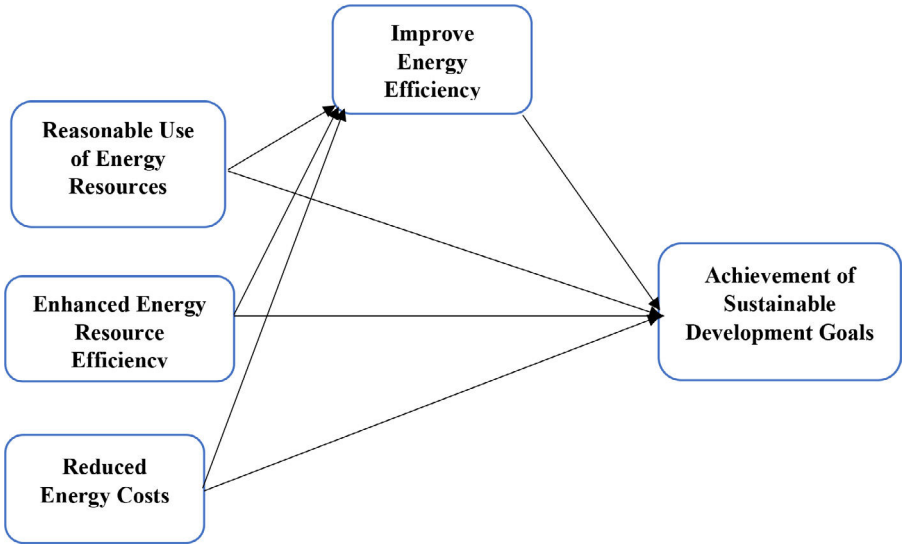

Fig. 2. Research framework.

Table 3
Fornell Larcker.

	EERE	IEE	REC	RUER	SDG
EERE	0.856				
IEE	0.423	0.819			
REC	0.402	0.395	0.905		
RUER	0.323	0.448	0.397	0.908	
SDG	0.279	0.508	0.509	0.440	0.799

Table 4
Cross-loadings.

	EERE	IEE	REC	RUER	SDG
EERE1	**0.884**	0.393	0.348	0.307	0.685
EERE2	**0.900**	0.443	0.351	0.320	0.731
EERE3	**0.888**	0.384	0.389	0.292	0.712
EERE4	**0.755**	0.232	0.276	0.212	0.549
EERE5	**0.842**	0.325	0.345	0.234	0.633
IEE1	0.390	**0.907**	0.336	0.441	0.463
IEE2	0.322	**0.802**	0.349	0.350	0.345
IEE3	0.352	**0.692**	0.347	0.261	0.466
IEE4	0.309	**0.860**	0.258	0.403	0.372
REC1	0.388	0.378	**0.859**	0.368	0.439
REC2	0.373	0.345	**0.956**	0.376	0.484
REC3	0.342	0.386	**0.864**	0.350	0.460
REC4	0.348	0.316	**0.935**	0.340	0.456
RUER1	0.299	0.423	0.358	**0.950**	0.401
RUER2	0.314	0.405	0.393	**0.837**	0.429
RUER3	0.262	0.386	0.324	**0.934**	0.363
SDG1	0.437	0.423	0.454	0.427	**0.682**
SDG2	0.560	0.384	0.391	0.393	**0.727**
SDG3	0.627	0.331	0.369	0.313	**0.803**
SDG4	0.712	0.410	0.370	0.347	**0.886**
SDG5	0.681	0.399	0.412	0.313	**0.850**
SDG6	0.678	0.489	0.460	0.345	**0.829**

The HTMT ratio results show that the values of the ratios are lower than 0.85, indicating low correlation among the variables and discriminant validity. These values are given in Table 5.

The structural model assesses the associations among the variables, and the results of the direct path reveal that reasonable use of energy resources, enhanced energy resource efficiency, and reduced energy costs have positive linkages with SDG for the manufacturing industry in China. Thus, H1, H2, and H3 are accepted. The results indicate that if there were a 1% change in EERE, the SDG would increase by 0.621%, and vice versa. The results also show that if there were a 1% change in REC, the SDG would increase by 0.163%, and vice versa. Moreover, a 1% change in RUER, would increase SDG by 0.118%, and vice versa. Finally, a 1% change in IEE, would increase SDG by 0.128%, and vice versa. These relationships are presented in Table 6.

The structural model also assesses the indirect associations among the variables and the results of the indirect path show that improved energy efficiency mediates the linkages of reasonable use of energy resources, enhanced energy resource efficiency, reduced energy costs, and the SDGs of the manufacturing industry in China. Therefore, H4, H5, and H6 are accepted. These relationships are presented in Table 7.

Table 5
Heterotrait monotrait ratio.

	EERE	IEE	REC	RUER	SDG
EERE					
IEE	0.476				
REC	0.436	0.449			
RUER	0.353	0.516	0.434		
SDG	0.758	0.590	0.567	0.501	

Table 6
Direct path.

Relationship	Beta	S.D.	T Statistic	P Value	L.L.	U.L.
EERE -> IEE	0.258	0.049	5.292	0.000	0.165	0.351
EERE -> SDG	0.621	0.035	17.840	0.000	0.552	0.687
IEE -> SDG	0.128	0.039	3.240	0.001	0.048	0.200
REC -> IEE	0.174	0.059	2.938	0.003	0.056	0.281
REC -> SDG	0.163	0.038	4.266	0.000	0.088	0.233
RUER -> IEE	0.295	0.058	5.051	0.000	0.182	0.409
RUER -> SDG	0.118	0.040	2.947	0.003	0.033	0.194

Table 7
Indirect path.

Relationship	Beta	S.D.	T Statistic	P Value	L.L.	U.L.
EERE -> IEE -> SDG	0.033	0.012	2.641	0.009	0.011	0.060
RUER -> IEE -> SDG	0.038	0.014	2.610	0.009	0.012	0.069
REC -> IEE -> SDG	0.022	0.011	2.071	0.039	0.004	0.045

Discussion

The study results indicate that the sharing economy benefit of reasonable use of energy resources, has a positive association with SDG achievement. This result is supported by Govindan et al. (2020), who show that, in a sharing economy, two or more individuals or companies collectively or cooperatively use resources (natural, physical, and human). When more entities share energy resources, any misuse, stealing, or illegal use can be checked and overcome. Reasonable use of energy resources helps achieve SDGs in areas such as health, social welfare, inequality reduction, and climate action. Hence, the reasonable use of energy resources in a sharing economy improves sustainable development. These results are supported by Laukkanen and Tura (2020), who shed light on the reasonable use of energy resources as an advantage of a sharing economy with a role in achieving SDGs. According to the study, the adoption of a sharing economy gives various individuals and corporations the right to equally and appropriately use energy resources. This meets the needs of the majority of the public and, with a reduction in the misuse or excessive use of energy resources, saves the environment from polluting effects. In addition, the study outcome, that reasonable use of energy resources has a positive association with SDG achievement, is similar to the findings of Shereni (2019), who shows that a sharing economy improves the reasonable use of energy and helps achieve SDGs.

The study results indicate that the sharing economy benefit of enhanced energy resource efficiency has a positive association with SDG achievement. This result is supported by Leung, Xue and Wen (2019), who show that, in a sharing economy, technologies, logistics, and infrastructure are shared by users, and thus, energy resources decrease. This decrease in the use of unclean energy reduces the adverse impacts of domestic and economic practices on the environment, such as oil degradation, unclean water, air pollution, and loss of livestock. This promotes sustainable development within the country. These results are consistent with Plewnia and Guenther (2018), who reveal that, in countries with sharing economies, a socioeconomic concept is employed in domestic economic activities, and the aggregate consumption of energy resources is decreased. As energy is a great source of environmental deterioration and a threat to sustainable development, enhanced energy resource efficiency helps the country achieve its SDGs. These results validate the findings of Ma, Lan, Thornton, Mangalagiu and Zhu (2018), who state that a sharing economy reduces the ownership of resources or processes which require energy. The enhanced efficiency of energy resources leads to SDG achievement. Moreover, this result matches that of past studies

such as Boar et al. (2020), which reveal that the sharing economy improves energy resource efficiency, which helps achieve SDGs.

The results reveal that the sharing economy benefit of reduced energy costs is positively correlated with SDG achievement. This result is supported by Hu, Liu, Yuen, Lim and Hu (2019), who find that a sharing economy is a source of cost reduction for business organizations which enables them to increase profitability. These increased profits can be used to mitigate environmental impacts, carry out research and development activities for innovation, or increase the scope of business activities. The reduction of pollution, innovation, and industrial growth are SDGs. These results agree with the study of Pouri and Hilty (2018), who state that in a sharing economy, people or corporations do not buy all their resources but rent them from peers. They can overcome the costs of resources and, similarly, rent out the resources in their ownership to save money. The saved costs of the sharing economy can be used to reach the goals of sustainable development. These results are consistent with Sung et al. (2018), who highlight the major advantage of a sharing economy, reducing the cost of access to resources. On one hand, owners save money by renting out resources during idle time, and on the other, people who could not afford resources have access to them. Both parties spend the saved resources on the economic development and growth which is part of the SDGs. The current study shows that reducing energy costs has a positive association with the achievement of SDG, similar to the findings of Olabi et al. (2022), who show that a sharing economy reduces the costs of energy and helps achieve SDGs.

The results show that improved energy efficiency is a mediator between sharing economy benefits, such as a reasonable use of energy resources, and SDG achievement. These findings agree with Gössling and Hall (2019), who suggest that improved energy efficiency is helpful to almost all SDGs, as it guarantees a clean environment by which SDGs are directly or indirectly affected. Energy efficiency is also improved by reasonable use of energy resources. Hence, this study shows a mediating impact of improved energy efficiency on the association between reasonable use of energy resources and SDG achievement. These results are in line with Ciulli and Kolk (2019), who show that, by applying a sharing economy, the misuse of energy resources such as natural gas, oil, coal, biomass, and ethanol is far less. Thus, energy resources that are limited in quantity in any region are not wasted, and thus, energy efficiency improves the economy. Any improvement in energy efficiency within an economy leads the economy towards sustainable development.

The results indicate that improved energy efficiency is a mediator between the sharing economy benefit of enhanced efficiency of energy resources and SDG achievement. This result agrees with Curtis and Mont (2020), who suggest that, in a sharing economy, technologies, logistics, and infrastructure are used in cooperation with other individuals or businesses. As these resources are useful to all parties, everyone looks after the quality of the resources. As a result, the efficiency of the energy resources increases, meeting greater energy needs with less resources and having fewer negative impacts on the environment, society, and economy. Thus, the achievement of SDGs becomes easier. The results show that improved energy efficiency is a mediator between the sharing economy benefit of reduced energy cost and SDG achievement. This result agrees with Eckhardt et al. (2019), who say that, when technologies or processes are shared with others, the costs of the energy resources are distributed, and earnings increase. Reduced costs and enhanced profits improve the technologies' capacities to work with minimum energy, and energy efficiency plays a significant role in achieving the SDGs which are based on environmental quality.

Theoretical and empirical implications

The current study has theoretical implications that add to the literature on SDGs, the main focus of the study. The study sheds light on sharing efficiency and its role in achieving SDGs. The study analyses three sharing economy benefits: reasonable use of energy resources, enhanced efficiency of energy resources, and reduced energy costs, and their impact on SDG achievement. In the literature, the sharing economy and its relation to SDG achievement is the subject of many studies, and many authors look at its advantages for economists and individuals. However, the individual benefits of a sharing economy and its impact on SDG achievement have been paid less attention. The present study differentiates itself by exploring sharing economy benefits such as reasonable use of energy resources, enhanced efficiency of energy resources, and reduced energy costs individually in relation to SDG achievement. Previous studies deal with improved energy efficiency as an advantage of a sharing economy as a determinant of SDG achievement. However, improved energy efficiency is not taken as a mediator between sharing economy benefits and SDG achievement. The current study examines improved energy efficiency as a mediator between the sharing economy benefits of reasonable use of energy resources, enhanced efficiency of energy resources, reduced energy costs, and SDG achievement.

The current study can guide policymakers to develop policy that improves the sharing economy and enhances SDG achievement. Over time, the world is becoming more populous. In any country, the increase in population causes an increase in both the domestic and economic use of natural resources, including energy. The exponential increase in economic activity and the wide use of natural resources reduces the quantity of those resources and damages the natural environment, adversely affecting future development. Under these circumstances, this study presents a substantial guideline, as it addresses the issue of energy usage with a detailed description of how energy resources can be reduced or made more efficient, and how SDGs can be achieved. This study guides economists, environmental regulators, and commissions formed for sustainable development, to design policies to encourage a sharing economy for the achievement of SDGs. The article provides guidelines for regulators regarding SDG achievement using a sharing economy. This study shows that SDGs can be achieved with the incorporation of a sharing economy, which has benefits including the reasonable use of energy resources, enhanced efficiency of energy resources, and reduced energy costs. The study reveals that, through a sharing economy with the benefits of reasonable use of energy resources, enhanced efficiency of energy resources, and reduced energy costs, energy efficiency can be improved, which assures SDG achievement.

Conclusion

China is the world's most populous country. Although the country is rich in natural resources, including energy resources (oil, coal, gas, biomass, and biofuel), natural resource consumption is greater, and the environmental impacts are severe. Under this conditions, future development is uncertain. The current study focuses on the conditions in China and the achievement of SDGs. The study's main objective is to trace the impacts of sharing economy benefits, such as reasonable use of energy resources, enhanced efficiency of energy resources, and reduced energy costs, on the achievement of SDGs. One objective is to explore the mediating role of improved energy efficiency in the sharing economy benefits of reasonable use of energy resources, enhanced efficiency of energy resources, reduced energy costs, and SDG achievement. A research survey of manufacturing organizations in China provides quantitative evidence for the interrelationship of the sharing economy benefits of reasonable use of energy resources, enhanced energy resources, reduced energy costs, improved energy efficiency, and SDG achievement.

In addition, the study findings show that a sharing economy encourages the reasonable use of energy resources. The suitable use of energy resources, without wasting or misusing them, improves

equality, the environment, health, welfare, life on land and underwater, and consistency in economic progress. In a sharing economy, energy resources are used by several users. The efficient and optimal use of energy resources keeps the environment (air, land, water), and the health of living organisms safe, and thus helps to achieve SDGs. The study implies that one major benefit of a sharing economy is reducing energy costs, which increases the funds available for achieving SDGs. The study suggests that sharing economy benefits, such as reasonable use of energy resources, enhanced efficiency of energy resources, and reduced energy costs, improve energy efficiency, which assists in achieving SDGs.

Limitations and future directions

There are several limitations to this study, which, it is hoped, can be addressed by future studies. This study addresses only the sharing economy benefits of reasonable use of energy resources, enhanced energy resource efficiency, and reduced energy costs. For a more comprehensive and valid study, the analysis of more of the elements that can affect SDG achievement would be necessary. Likewise, the findings of this study are based on the content of the questionnaires and the information drawn from them. The extent and quantity of the information obtained determines the validity of the nexus addressed. For more reliability and validity, future authors could adopt other methods to acquire and analyze data. Moreover, future studies could also analyze improved energy efficiency as a moderator of sharing economy benefits such as reasonable use of energy resources, enhanced efficiency of energy resources, reduced energy costs, and SDG achievement.

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