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The Effect of Energy Security on Oil Export (The Case of Iran)

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Abstract
Energy trade plays a crucial role in the growth and development of countries, especially for IRAN as one of the world's largest exporters of oil in the world. Identifying the factors that affect exports and their development, along with promoting export performance in the energy sector should be the focus of policy and strategic planning in an internationally competitive environment. Given the importance of energy trade in Iran, this study aimed to analyze the effect of the energy security index on oil exports using the Fully Modified Ordinary Least Square (FMOLS) method. The findings of study reveal that oil exports are negatively affected by oil energy security, i.e., as this unit deteriorates, the index of oil exports increases by over 3%. Furthermore, the study found that GDP and the exchange rate have a positive impact on oil exports, whereas energy prices and population density have an adverse impact. Furthermore, the study's results demonstrate that GDP and exchange rate have a positive effect on oil exports. Based on the findings of this study, first, it can be argued that an independent and powerful institution is essential to monitor and enforce policies, standards, and regulations to enhance energy efficiency. Second, upgrading old technologies, developing new ones, scaling up actions on energy efficiency, and increasing public knowledge and understanding about energy can reduce energy intensity and increase savings. Last but not least, a transition from high-consumption to low-consumption technologies designed to reduce energy consumption and maximize efficiency can increase oil exports.
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1. Introduction:

Energy is the backbone of the economy and plays a key role in economic growth and poverty reduction. Energy security has long been one of the most important goals of sustainable economic development that enhances welfare and alleviates poverty. Energy security is defined by the Asia-Pacific Energy Research Center as "the ability of an economy to secure energy" (Valdes, J. (2021).

Throughout the literature on energy security, there is considerable controversy about the way energy security is conceptualized, as well as what components and dimensions it should include. A well-defined concept of energy security is essential to effectively articulating energy analysis. In addition to theoretical discussions, conceptualizing energy security is crucial. A proper concept of energy security is imperative to formulating, implementing, and evaluating energy policies since energy security always reflects strategic energy policy intent (Alekhina, V. (2021).

Socioeconomic development is profoundly affected by the availability of cheap energy. As a result, there is an ever-increasing global demand for energy (Mulugetta et al, 2019; Pueyo and Maestre, 2019). Consequently, providing secure, accessible, affordable energy should be a fundamental principle across all energy policies. The energy supply disruption can have severe economic, social and political effects on both developed and developing countries (Azzuni and Breyer, 2020).

Furthermore, to develop an economy appropriately, it is imperative to have a resilient energy supply system to avoid distribution losses caused by disruptions. Energy production and consumption should be both eco-friendly and efficient (Herrero et al., 2020). These factors demonstrate the importance of energy security at all levels. Poverty eradication and energy accessibility are key elements of energy security that must be taken into consideration. In order to achieve energy security, countries must take all necessary measures to supply affordable and efficient energy market, which is eco-friendly and sustainable (Jarosław, B. Magdalena, T. 2021).

The concept of global energy governance has emerged as a multidisciplinary approach to deal with energy market challenges such as energy sustainability, energy poverty, global warming, energy justice, greenhouse gas

emissions, nuclear proliferation, resource management, and climate change. Consequently, numerous research projects have been conducted concerning the global governance of sustainable energy transitions across a range of disciplines (Valdes, J. 2021). Recently, energy security is one of the most popular and controversial topics of research in energy market studies. The concept of energy security is always a reflection of energy policy's strategic goals, which means that policy formulation, implementation, and evaluation would not be possible without it. Policymakers and economic agents can only establish sustainable energy systems by analyzing and developing a secure energy infrastructure (Novikau, A.2022).

Crude oil is one of the most important sources of energy in the world. As reported by Energy Information Administration[1], 37% of the world's electricity comes from crude oil. Accordingly, crude oil is a major internationally traded commodity, with a significant impact on economic and political development and international relations, especially for the world's largest exporters like Iran. There are two groups of countries in the world based on their global energy reserves. The first group consumes the largest amount of energy, while producing the least amount of oil. For example, there are only 7% of crude oil reserves in the OECD group of developed countries, which burn 62% of the world's oil. The first group of countries obtains 34% of their oil needs from countries in the second group, which have the largest oil reserves. This indicates that the first group of countries are heavily dependent on the second group for their oil requirements. In the second group, the countries of the Middle East, with 48% of the world's oil resources, consume only 8.3% of this energy, while the Europeans with only 1% of the world's oil reserves consumed 15% of the world's oil in 2019.

In general, the level of energy consumption in developed countries is relatively higher than in emerging economies. It is evident that energy contributes to economic activities, productivity growth, the development of human resources, and the improvement of people's living standards. Therefore, energy consumption and exports play an essential role in intensifying economic growth (Thapa-Parajuli, R., Aryal, S., Alharthi, M., & Paudel, R. C 2021).

Iran, known to be one of the prominent players in the global oil market, holds a pivotal position in the world's energy trade. The country's economy heavily relies on its energy sector, particularly oil exports, for its growth and development. Recognizing the criticality of energy trade in Iran, this research endeavors to delve deeper into the relationship between energy security and oil exports through a comprehensive analysis utilizing the Fully Modified Ordinary Least Square (FMOLS) methodology. The field of energy security has seen a proliferation of studies in recent years, yet this study stands out from its predecessors in several keyways. Firstly, it draws its data from one of the world's most consumed energy commodities - oil - providing a unique perspective on the subject. Secondly, this study offers a comprehensive overview of energy security that builds upon and expands the findings of previous studies. Thirdly, rather than adopting a purely historical approach, this study takes a forward-looking perspective, offering valuable insights for predicting crude oil prices and volatility in the future. With its innovative and nuanced approach, there is no doubt that the results of this study will make a significant contribution to the existing body of knowledge on energy security.

The practical implications and noteworthy contribution of this study can be summarized as follows: First, given its unique geographical location, rich historical heritage, complex political landscape, and diverse social and economic conditions, the findings of this study hold immense significance for Iran. As a significant player in the global oil market, Iran's economy heavily relies on oil exports for its growth and development, making energy trade a critical component of its economic well-being. Therefore, understanding the impact of energy security on oil exports is of utmost importance for policymakers and stakeholders in Iran as they seek to craft effective energy policies and make informed decisions. Second, this study provides a general overview of energy security that expands and develop the findings of previous studies. Third, the findings of this research contribute to a deeper understanding of the interaction between energy security and economic growth and provide valuable insights into the ongoing discourse on energy policy in Iran. By examining the relationship between energy security and oil exports, the study aims to provide a nuanced perspective on the challenges and opportunities facing Iran's energy sector and offer recommendations that can help enhance the country's energy security, promote sustainable economic growth, and ensure the long-term viability of the energy trade sector.

This paper is structured as follows Section 2 discuss the recent literature on the drivers of energy security; the database and methods are explained in Section 3; the major analysis and empirical findings are discussed in Section Finally, Section 4 concludes.

2. Literature Review:

The term "energy security" came to light in 1973 after the first oil crisis. Furthermore, the Kyoto Protocol, which was signed by 150 countries in 1997, has redefined energy security throughout the world. According to recent studies, energy security is a key driver of policy decisions (Chalvatzis and Ioannidis, 2017)

In spite of the fact that energy security is a key objective of energy policy, it has not yet been universally

[1] https://www.eia.gov/

defined. A review of 104 papers analyzing energy security in countries and regions revealed that the definition of energy security is highly context dependent. Despite this diversity, most discussions on energy security are based on the 4 A's: Availability, Affordability, Accessibility, and Acceptability (Sutrisno, A., Nomaler, Ö., & Alkemade, F. (2021).

Some studies focused on the security of energy supply as a key consideration. For countries that are not rich in fossil fuel resources (coal, oil, or gas), energy security is mainly achieved through imports. The energy network resulting from trade relations is shaped by geopolitical factors such as foreign policies, economic characteristics of importing countries and the strategic considerations of incumbent suppliers (Zhang et al, 2014).

The incumbent suppliers include member of the Organization of Petroleum Exporting Countries (OPEC) and the Gas Exporting Countries Forum (GECF). However, each importing country has a different incumbent. Furthermore, energy network changes are also driven by the emergence of non-traditional suppliers, technological developments, national energy infrastructure agendas, cultural proximity, bilateral and multilateral trade agreements and path dependence. In spite of the importance of these factors, which are widely acknowledged, there has not been a systematic analysis about them (Sutrisno, A., Nomaler, Ö., & Alkemade, F. 2021).

Moreover, energy security has been identified as an important driver of sustainable socio-economic growth in all nations. It also significantly reflects sustainable energy supply, energy efficiency and environment protection within sustainable development (Chung et al., 2017). Therefore, energy security has been studied extensively, mainly in the context of the energy security assessment, the integrated simulator model, the Geothermal Security Assessment Template and power supply chains (Rafique et al, 2017). Energy security is significant due to the growth of environmental changes that have great impacts on human life. Accordingly, another strand of literature examined the relationship between climate change and energy security (Dellano-Paz et al., 2016).

Energy is one of the most critical inputs for production, but its consumption growth is generally slower than the growth of real GDP due to advances in energy efficiency and sustainability. Through its interactions with other social and industrial segments, energy plays a crucial role in the economic performance of countries, even though it makes up a relatively small share of GDP. Short-term energy supplies must be protected in order to achieve inclusive and sustainable economic growth. In this way, long-term energy security will be achieved through sustainable energy markets. Increasing energy reserves can lead to sustainable energy markets in the short run, but long-term sustainability and security are challenging. It is essential to adopt the best energy policies in order to ensure a secure, sustainable, and resilient energy market (Alekhina, V. 2021).

Even though energy insecurity is one of the most significant risks on economies, most studies only focused on analyzing a limited set of indicators. The impact of energy insecurity on economic growth is rarely examined in previous studies, despite the fact that it is one of the most significant risks to the economy in both developed and emerging economies. Hence, the effect of energy security on economic growth is a significant gap in previous studies that needs to be filled. In spite of its popularity in assessing energy security, few studies have examined its application to economic growth. For example, Le and Nguyen (2019) examined whether energy security increases economic growth in several countries. They found a positive relationship between energy security and economic growth. Samawi et al. (2017) examined the impact of energy security on economic growth in oil-importing countries and concluded that energy supply is strongly correlated with growth in the economy.

The finding of previous studies reveal that energy security has a direct impact on macroeconomic variables, which makes it of great importance (Killian, 2008; Hamilton, 2009; Yoshino and Taghizadeh-Hesary, 2016; Taghizadeh-Hesary et al., 2016; Alekhina and Yoshino, 2018). Moreover, the insecurity in energy supply has negative impacts on commodity prices, including energy, food, and services. The study undertaken by Taghizadeh et al. (2019) and Sachs et al. (2019) found that limited energy sources such as oil, gas, and coal reduces the flexibility of the economy and increases its vulnerability to energy price fluctuations. In accordance with the Sustainable Development Goals (SDGs) and the Paris Agreement, increasing the share of green energy in the energy portfolio will not only reduce greenhouse gas emissions, but also enhance energy security (Alekhina, V.2021).

Oil, as a strategic resource with an unbalanced distribution, has political characteristics due to the product characteristics of cross-border transactions. Political uncertainties, such as geopolitical risks, have also become important factors that affect the performance of the oil market (Alqahtani, A,Taillard, M. (2019). The interaction between uncertainty risk and oil price is not constant. Uncertainty risk factors have different directions, intensities, and durations. For example, outbreaks of social and political risk events, such as terrorism, usually last for a short period, while economic crises, such as the global financial crisis, are more profound and last longer (Feng, Y., Xu, D., Failler, P., & Li, T. (2020).

However, it is important to note that crude oil has high volatility characteristics and a large range of fluctuations. There are also significant differences in the sensitivity and vulnerability of the oil market in the face of different levels of political or economic uncertainty. It is vital to analyze the effects of different types of uncertainty risk events on the oil price volatility comprehensively (Song, Y., Chen, B., Wang, X. Y., & Wang, P. P. 2022).

Oil plays a fundamental role in the industrial chain, so economic recession often results in a decrease in oil demand, making the energy market gloomy. As the oil market has become increasingly financialized, risks caused by uncertainty in economic policies in other financial markets can have a swift effect on the oil market, causing price changes. (Yang, L., & Hamori, S. 2021). Energy protection in useful resource-rich and energy-exporting countries are liable to outside shocks which could have profound and multiplying effects on non-aid sectors, capital formation, environmental programs, era transfer, and ordinary economic growth (Griffiths, 2017; Nepal and Paija. 2019).

Energy commodities, especially crude oil, play a critical role in industrializing and developing countries. In addition to providing revenue to oil-exporting countries, oil supports industrialization in oil-importing countries. The oil market has also been noted as a transmitter of shocks to other markets, causing instability. Hence, it becomes important to analyze all factors impacting Iran's oil exports to extend the findings of previous studies. As a result of energy security, this study examines all factors affecting Iran's oil exports.

3. Data

3.1. Data

In this study, a time-series dataset was employed, covering an annual period from 1997 to 2020. The dataset includes several key variables that were analyzed, including carbon oil exports, gas exports, energy security indices for oil, GDP per capita, exchange rate, population, and the price of crude oil. These variables were selected to provide a comprehensive picture of the relationship between energy security and economic growth in Iran.

The OPEC data center has provided data on oil exports and oil price. Energy security variables for oil were collected from the Energy Balance (https://irandataportal.syr.edu/). GDP and exchange rate variables were sourced from Iran Statistics Center (http://www.irstat.ir/), and the population from the world bank (https://www.worldbank.org/).

Table 1. Data description

Variable	Description	Source
Oil export	Total oil exports (thousand barrels per day)	OPEC
Security of oil energy	Ratio of oil import to consumption (million barrels of crude oil equivalent)	Energy Balance (Iran Data Portal)
GDP per capita	GDP per capita (million Rials)	Statistics Center
exchange rate	Average The average Iranian Rial to US Dollar (Rial)	Statistics Center
population	Population density (people per square kilometer)	World Bank
Oil prices	Rial/liter equivalent to crude oil	OPEC

3.2 Methodology

Fully Modified Ordinary least Squares (FMOLS)

This research uses the fully modified ordinary least squares (FMOLS) method to estimate the effect of the energy security index on oil exports. This method estimates the parameters of a collective equation and provides modified criteria that enable statistical inferences. To implement this method and obtain long-term parameters, examining cointegration among variables is essential. Consequently, it is imperative to first verify the unit root test and then assess the presence of the co-integrating vector among the variables. The linear regression model is assumed as the following relationship.

$$Y_t = \beta_0 + \beta_1 X_t + u_t$$

It is a vector $k-1$ of drift parameters, and V is a vector of sentences. In this case, even if there is a simultaneous relationship between X and U, the coefficient estimators are consistent with the OLS method; But generally, the asymptotic distribution of the OLS estimator is non-standard and will make statistical inference valid for coefficients with unusual t-statistics. To overcome this problem, it is appropriate to consider the relationship between u and V and their interval values. The fully modified least squares method accounts for this correlation in a quasi-parametric manner. FMOLS, presented by Phillips and Hansen (1990), is used to examine cointegration and long-term relationship; Because:

First, Engel and Granger's ordinary least squares method (OLSEG), although super consistent, is not asymptotically skew-free and normally distributed. Second, the OLS method for estimating population regression, which has a large sample size and the number of observations, brings consistent and efficient results; But in small samples, the OLS method estimators have a non-normal distribution, and the results are consistent and also the t-statistic will not be asymptotically reliable. In such a situation, the FMOLS method is suitable. In order to use the FMOLS method and obtain long-term parameters, it is necessary that there is an association of variables (1) I; Therefore, it is required to check the unit root test and then the covariance vector between the variables

(Amarawickrama and Hunt (2008)). In small samples, FMOLS provides better results compared to Johanson's method. On the other hand, the advantage of this method compared to Johanson's method is that it is not affected by the length of the interval; While the results obtained from Johanson's method are strictly based on choosing the optimal interval. Also, Phillips showed that FMOLS estimations are asymptotically efficient as Johansson's method in conditions where all variables are endogenous.

3.3 Empirical Results

This part examines energy security on oil export using FMOLS model. The dataset runs from 1 January 1997 through 31 December 2020 and consists of the yearly time-series variables described in the Data section.

3.4 Unit root test

In examining time series, the main assumption is that the series is stationary (Esmaeili and Rafei, 2021). So, for preventing Misleading results the condition of the variables should be checked. Due to the capability to identify the variable's serial correlation, the ADF unit root test introduced by Dickey and Fuller (1979) was used. In accordance with this study to survey the stationarity (Ueda et al, 2020). The null hypothesis of this test shows that the variable is non-stationary.

3.5 FMOLS Estimation and Granger Causality Test

Unit Root Test

Stationary test is one of the prerequisites for estimating a suitable regression model. In this section, in order to avoid the false regression problem, the variables' stationarity test has been performed using the generalized Dickey-Fuller (ADF) test. In this test, by rejecting the hypothesis of non-stationarity or the existence of a unit root of the variables, it is rejected.

Table 2 shows the results of the unit root test at the level for all research variables

Table 2: The results of Dickey-Fuller's generalized unit root test on the surface

Variable	ADF		Stationary order
	Intercept	Trend & intercept	
Oil export	-3.004861 (0.6816)	-3.632896 (0.1259)	I (1)
Oil energy security	-3.004861 (0.0984)	-3.632896 (0.2925)	I (1)
GDP	-2.998004 (0.3416)	-3.622033 (0.9497)	I (1)
exchange rate	-2.998004 (0.9996)	-3.622033 (0.9953)	I (1)
population	-3.012363 (0.5487)	-3.644963 (0.1866)	I (1)
Oil prices	-3.004861 (0.1340)	-3.690814 (0.1743)	I (1)
Oil export	-3.020686 (0.0001)	-3.658446 (0.0002)	I (1)
GDP	-3.004861 (0.0107)	-3.644963 (0.0117)	I (1)
exchange rate	-3.004861 (0.0210)	-3.632896 (0.0133)	I (1)
Population	-3.052169 (0.0027)	-3.710482 (0.0101)	I (1)
Oil prices	-3.012363 (0.0024)	-3.644963 (0.0128)	I (1)

3.6 Data and Methodology and Data

3.6.1 Model Specification

According to the aims of the current research, the variables entered the model as some factors affecting energy security. The purpose of this research is to investigate the impact of energy security on oil exports in Iran using data from 1997 to 2020. Therefore, to achieve this goal, the following model is considered.

Following the paper of Pavlović, D., Banovac, E., & Vištica, N. (2018), the model estimation framework is presented as follows:

$$EX_t = \beta_0 + \beta_1 SE_t + \beta_2 GDP_t + \beta_3 RE_t + \beta_4 P_t + \beta_5 POP_t + \varepsilon_t \quad (2)$$

The above equation is used separately for oil and in it, all the variables are logarithmic except SE (because it is in percentage form). In equation (1), EX represents the amount of export, SE presents the level of energy security, GDP I t resents the gross domestic product per capita, RE represents the exchange and repress, F it represses the price of one and is are present the population density.

In table 2, the definition and source of each variable are provided. The Tare FMOLS method was introduced and developed by Philips and Hansen (1990) and has an advantage for suitable corrections to overcome the inference problem (Oryani et al., 2021). So, the FMOLS is one of the most feasible options for estimating the long-run elasticities as it controls for the endogeneity and autocorrelation problems in the data (Merlin and Chen, 2021, Oryani et al., 2021). Generally, in the current paper first, the unit root test is used to check the stationarity of data. In the next step, for surveying the existence of long-run linkage, the Johansen cointegration test was employed. For estimation of the econometrics model, the FMOLS (fully modified ordinary least square) model was used to investigate the influence of different variables on energy security. In the last stage, the causality relationship between the variables is examined by the Granger Causality test.

3.6.2 Johanson-Jusilius cointegration test

As Table 3 shows, in both models, the Akaike and Schwarz-Bayesin criteria for interval two are minimal. Therefore, the optimal interval is two. After determining the number of optimal intervals using the VAR model, the Johansen-Juslius cointegration test should be performed to check the existence of a long-term relationship between the variables of the model. Based on the results of this test, if there is at least one co-occurrence vector between the variables of the model, it can be said that the existence of a long-term relationship between the variables of the model is proven. As the results of Table 3 show, in both models, the existence of a long-term relationship between the research variables cannot be ruled out.

		Oil model			
H_0	H_1	λ_{max1}	λ_{trace1}	0.05 *Critical Value*	*Prob*
r=0	r≥1	0/984173	249/0145	103/8473	0/0000
r=1	r≥2	0/944593	161/9480	76/97277	0/0000
r=2	r≥3	0/880519	101/1939	54/07904	0/0000
r=3	r≥4	0/831894	56/57745	35/19275	0/0001
r=4	r≥5	0/450410	12/13106	20/26184	0/0710
r=5	r≥6	0/268326	6/560815	9/164546	0/1516

3.6.3 Model estimation

As seen, all the variables have a single root of the first order. Also, in the previous section, the existence of collocation relationship between model variables was proved; Therefore, it is possible to use the fully modified ordinary least squares (FMOLS) method to estimate the coefficients of the research models In Table 4, the model estimation results using the FMOLS method are presented.

Table 4. FMOLS test long-run coefficients

Variable	Coefficient	Std. Error	Test Statistics	probability
Lglob	0.06	0.02	2.52	0.017
Lpenc	0.7	0.01	35.8	0.00
Lpgdp	-1.3	0.02	-65.11	0.00
$Lpgdp^2$	0.09	0.002	42.8	0.00
Vis	0.001	0.0004	2.4	0.01
$Dummy_{1984}$	0.2	0.007	28.2	0.00
$Dummy_{1991}$	0.02	0.006	3.1	0.004
$Dummy_{2010}$	-0.02	0.006	-3.7	0.00

Source:Authors' research results

According to the value of the adjusted coefficient of determination and also according to the results of the diagnostic tests, the presented model has a suitable fit.

4. Conclusion

One of the essential human needs that has maintained its importance since the beginning is energy. The way to meet this need and the scope of its use has changed over time. The goal of early humans was to provide more energy for heating and cooking until the occurrence of the industrial revolution in the West, and the industrial and military use of all types of energy increased its importance so that today energy plays an undeniable and central role in the development of countries. Today's advanced and emerging economies depend heavily on gas and oil and often importing it from other countries. The resulting pattern of extensive international trade in energy resources, whenever supply is concentrated or production capacities are limited, creates significant security

concerns.

In this regard, during recent decades, energy security has found a worthy place in energy discussions; In such a way that energy security is considered to be the availability of a sufficient amount of it at an affordable price to meet the demand and includes three fundamental concepts in the chain of today's energy developments, including price, continuity, and environment. Increasing and decreasing in the price of crude oil have caused many changes in the global economy, household budgets, production costs, and the instability and vulnerability of producing and consuming countries. Along with the supply chain, finding more efficient methods and less energy intensity is a step towards improving energy security and preserving natural resources. In foreign trade, energy in the export and import sectors has always been the focus of countries at the international level; In such a way, identifying the factors affecting export and its development, as well as the promotion of the export performance of the energy sector, are at the top of policies and decisions in the environment of international competition.

With 137.6 billion barrels of oil, Iran has the second largest oil reserves in the world (after Saudi Arabia) and is close to oil production centers. It plays a strategic role in global transactions. But what is proposed as the category of energy security in this regard; There are concerns about increasing consumption, the reduction of exhaustible reserves, the change in the policies of energy-demanding countries, and the impact on the cost of these resources. It should be noted that the international sanctions imposed on Iran in recent years have considerably impacted the declining trend of oil exports. Therefore, in this study, using the FMOLS method, the impact of energy security on the export of two oil and gas sectors in Iran during the period from 1997 to 2020 was investigated. According to the results, Iran's oil export trend is fluctuating and declining; according to which the level of oil energy security has a negative effect on its export; In such a way that by increasing (worsening) one unit of this index, the amount of oil exports decreases by more than 3%.

The results of also show the positive effect of GDP on the amount of oil exports, so that with a one percent increase in gross domestic product, the amount of oil exports increases by more than 5 percent, respectively. The exchange rate has a positive and significant effect on the amount of oil exports, so that with a one percent increase in the exchange rate, the amount of oil exports increases by more than 0.15 percent. In addition, the results of show that population density has an inverse and significant effect on oil exports; In such a way that with a one percent increase in population density, the amount of oil exports decreases by more than 12 percent. Finally, the results show that the price of energy has a negative effect on oil exports in such a way that with an increase of one percent, the price of oil decreases by more than 0.17 percent.

Suggestion Research

First, the application of laws and standards formulated to increase energy efficiency and its implementation and supervision by an independent and influential institution.

Second, the renewal of production technology in high-consumption sectors and the realization of energy prices can provide a basis for reducing energy intensity and increasing savings.

Third, providing low-cost facilities for transferring high-consumption technologies to low-consumption technologies that ensure the highest efficiency from the lowest consumption can increase exports in oil sectors.

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