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Assessing oil supply security of South Asia

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ABSTRACT

Energy security assessment provides a benchmark for policy analysis and identifies the challenges for ensuring energy supplies as well. This paper develops a composite index for assessing the oil supply risk of South Asian countries. The index is based on a comprehensive set of indicators including the ratio of imported oil over GDP, geopolitical risk, market liquidity, GDP per capita, ratio of oil imports over consumption, diversification, oil price volatility, US$ volatility and transportation risk. Results reveal that India is the least oil vulnerable country while Afghanistan and Bangladesh are the most oil vulnerable countries. India's leading score reflects a higher potential to change the oil suppliers while Afghanistan, Bangladesh, Bhutan, and Nepal have the least score confirming them as the highest supply risk associated countries. Policies such as adopting renewable energy technologies, generating nuclear power, diversifying export sources and cutting down oil subsidies can help reduce the impact of oil supply risk.

1. Introduction

Energy security is significantly affected by fossil fuel based energy carriers. After the two global oil crises, oil security has turned to one of the main political agendas. The extensive dependency on oil has led to an increase in the amount of oil.32% of electricity is being generated through oil worldwide, and at the same time oil accounts for 90% of transport energy globally [1]. Additionally, 60% of the world's oil is being imported from the international market, and oil importation faces many risks due to unstable economic situation, insecure political issues, and by ambiguous demand and supply [2].

From 1990 to 2015, world's total oil imports have risen by 80%. However, there is uncertainty in future demand and supply of oil since the relations between oil consumption and oil supply countries keep varying. Moreover, country-specific policies in the future may influence oil demand and supply. The oil imports risks including import cost, exporter's oil capacity, intrastate conflict of oil-producing states, transportation risk, environmental risk and abrupt demand and other economic factors are the major sources of influencing oil supply security for oil consumers [3]. Most of the major oil exporters situated in the North Africa and the Middle East having unstable economic and insecure political environment. The highly dangerous chokepoints such as Hormuz and the straits of Malacca increase the oil supply vulnerability. Moreover, oil supply threats affect the oil supply security and other energy sources so the understanding of oil supply vulnerabilities requires a comprehensive and rigorous analysis.

The purpose of this paper is to develop a composite index for assessing oil supply security of South Asian countries, which combines various aspects of an indicator in a transparent and systematic way. The composite index provides a systematic assessment, international rankings, oil supply profile and prerequisite understanding of oil security challenges. Asia is highly dependent on oil imports, and it is one of the most vulnerable regions regarding oil security. With affected oil supply, most of the countries in this region face the persistent shortage of oil. As a result of their high dependence on external oil suppliers, these countries are facing high-energy shortage from 1990 to 2015. Often South Asian countries have faced oil shocks many times, which is not a good signal for the healthy energy supply of any nation [4].

Numerous studies are concerned with the methods for measuring oil supply security. For instance, Zhang et al. [5] developed a DEA like indicator system for China's oil import supply security, composed of supply risk, economic risk, trade out

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risk and dependence risk. Blum and Legey [6] conducted the study of energy scarcity situation and surplus energy opportunities by using theoretical approach of demand and supply. Asif and Muneer [7] and Cohen et al. [8] measured the energy security and oil diversification by using Herfindahl–Hirschmann index (HHI). Vivoda [9] studied the energy security and diversification strategy of oil importing countries by using diversification of imported oil. Meanwhile, Gengand Ji [10] proposed a multidimensional energy security indicator system while Yao and Chang [11] proposed an investigational framework of oil firms regarding current energy growth and potential energy resources. Kim and Kim [12] continued to propose a quantitative indicators system to measure the energy security and sustainable development index. Jun et al. [13] measured the cost of price volatility, energy security supply and the concentration of energy demand and supply by using Herfindahl–Hirschmann index (HHI). Greene [14] measured an oil supply security metrics by developing a stochastic simulation model. Gupta [15] used the principal component analysis (PCA) to develop an oil vulnerability index of 26 oil-importing countries.

Also growing literature is available on energy security assessment. [16,17] sought to measure the energy security supplies for importing countries by using import dependence, diversification capability of oil supply sources, geopolitical risk and distance between oil supplies and importers [18]. Zhang [19] pointed out that diversity in the geographical source is a crucial way to escape oil supply risks and ensure oil security. China's dependency on the Strait of Malacca checkpoint has steadily increased for oil transportation [20]. It directly affects the security, safety, and smoothness of the shipping route of oil. In this perspective, the Malacca Dilemma has greatly destabilized oil import security of China.

Earlier studies mainly focused on certain aspects in indicator selection, and often used traditional techniques to aggregate the indicators. In addition, they did not pay attention to weights of each indicator and does not provide a common acceptability of the study. None of the previous studies combined the most relevant comprehensive set of indicators and used composite indicator approach to measuring the oil supply risk. This paper focuses on the methodological framework of quantitative risk assessment of oil disruption. We develop a comprehensive set of the indicators system, which evaluates and explores the inter-relationship among all indicators and combines all these indicators by a mathematical programming approach into Composite Indicators (CI) with restrictions on assigning the weights to each sub indicator. Oil supply risk of South Asia has been evaluated through CI between 2001 and 2015 and analyses are carried out to provide a roadmap for policy makers. Unlike others, this study assesses the oil supply risk of South Asia by a holistic manner and makes a significant contribution to the existing literature. Our contribution also includes an empirical estimation of oil supply disruption. We remove the shortcomings of other studies because the existing literature assumes that domestic oil production is free from supply risk, but our study shows a significant impact on oil supply disruption. Nevertheless, due to data unavailability, we have not considered some indicators, i.e. “country-wise” specific oil policies, strategic petroleum reserves, foreign exchange reserves and environmental risk factors which directly or indirectly affect the sources of oil supply risk.

The remainder of this paper is as follows: Section 2 explains the indicator system of risk identification. Section 3 contains methodology adopted in this paper while section 4 presents data. Results have been discussed in section 5. Section 6 concludes the paper and put forward the policy implications.

2. Indicators system of risk identification

2.1. Supply risk

Oil supply risk measures the availability and accessibility of oil supply. Supply risk indicators are used to evaluate the risks of physical disruption [21]. An oil supply risk indicator has been designed to measure the short term as well as long-term oil supply risk. Supply risk considers the sudden disruption of oil supply, which cannot be overcome instantaneously through the market. This type of disruption can also not be substituted with alternative energy type. Therefore, we propose an aggregate supply risk and then combine supply risk indicators with all other indicators in a mathematical CI, which differentiate our work from other studies. Our results justify each risk factor with sub-indicators and evaluate the supply disruption in a specific country as well as in a specific energy market. Following two precise indicators are used for the supply risk evaluation:

(i) Liquidity

Liquidity is a major component of geopolitical risk. Unlike Zhang et al. [5] who measured this component as a ratio of country's oil imports to country's total oil consumption, we have measured this market liquidity as the ratio of country's oil imports to world's oil imports because exporting countries' consumption is not available for import purposes.

$$\mathrm{MLQ} = \frac{\mathrm{IMSA}}{\mathrm{IMPW}} \tag{1}$$

where MLQ is market liquidity, IMSA is the oil imports of importing country and IMPW is the total oil imports of the world.

(ii) Geopolitical oil risk

Oil supply vulnerability is considered as exposure of an economy to geopolitical oil supply risks, which is the major and leading source of oil supply risk. Unlike Gupta [15] we focus on the short-term as well as long-term geopolitical risks of oil supply disruptions. Geopolitical oil risk is defined as the exposure of an economy to physical oil supply disruption. The root causes of geopolitical oil supply risk are strategic control of oil supply, breakdowns in the political and economic situation, war, government failure and unstable political system of oil exporting countries. It also affected due to the strategically motivated control of supply by oil exporting countries or breakdowns in political and economic systems [14]. The Herfindahl–Hirschman Index (HHI) index is considered as a traditional method of oil diversification index and is used to calculate the degree of concentration of oil supply;

$$\mathrm{HHI} = \sum_{i=1}^{N} W_{ij}^2 \tag{2}$$

However, we have added composite country risk factors, which are taken from the International Country Risk Guide (ICRG) and resemble a modified HHI Index;

$$\mathrm{HHI} - \mathrm{CR_j} = \sum_{i=1}^{N} W_{ij}^2 \times \mathrm{CR_j} \tag{3}$$

where $W_{ij} = X_{ij}/\sum X_{ij}$, X_{ij} is the share of suppliers j in total oil imports of country i,N stands for the number of total oil suppliers of i, $I_j$represents oil imports of country i from country j, CR is the country risk; where a value of 100 is considered for low risk and