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Measuring external oil supply risk: A modified diversification index with country risk and potential oil exports

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ABSTRACT

External oil supply risk is an important aspect of energy security and oil import diversification is viewed as one of the most effective measures to reduce supply risk. By using the diversification index approach, this research attempts to assess external oil supply risks of oil importers with consideration of two key factors associated with oil suppliers, country risk and potential oil exports capacity. The former can be used to reflect the oil supply risk associated with oil suppliers' macro-economic and socio-political stability and the latter is directly related with the physical availability of oil. The empirical research on China, Japan, the US and EU demonstrates that Japan's oil importing strategy is more concerned about potential exports of oil suppliers than country risk; the EU's oil imports have a good balance between country risk and potential exports of oil suppliers; the US has successfully diversified its oil imports to maintain the security of its external oil supply. With the rapid increase in oil demand, China has changed its oil import policy by expanding oil trade partners and switching to suppliers with high potential oil exports. Some further suggestions are presented for China to ensure its oil supply security in the future.

1. Introduction

With the rapid economic development, China became the second largest oil importing country in 2009; its crude oil import dependency reached 57% in 2012 [1]. Compared to the domestic oil supply, external oil supply is still a more important aspect of energy security for China. China's oil import dependency is expected to continue to increase and may surpass 60%[1] after 2015 [2]. The "12th Five Year Plan of Energy Development in China"[2] says that oil import dependency will be controlled at 61% in 2015. Increasing reliance on imports exacerbate a country's vulnerability to the effects of oil shocks as risks occur in the oil importing process [3]. As a result, much attention has been paid to ways of measuring and controlling the external oil supply risk by the policy-makers and the academia of China [4–8].

External oil supply risk has been considered to be an important aspect of energy security since the first oil crisis when oil price surged because of the Arab oil embargo in 1973–74, which caused serious damage to most countries' economies, especially the US and other developed countries. In general, energy security is defined as the availability of a regular energy supply at an affordable price [9]. The external oil supply risk faced by oil-importing countries mainly consists of price fluctuations and supply disruption. Regarding the uncertainties emanating from price fluctuations, external oil supply risk is usually measured by portfolio techniques [4,5,8,10,11,12]. By using the portfolio approach, oil supply risk can be divided into systematic risk and specific risk. The former is non-diversifiable risk, which typically affects most suppliers and in contrast, the latter is unsystematic or diversifiable risk, which is more unique or specific to individual suppliers and normally affects a smaller number of suppliers. As China has little or no bargaining power in respect of oil price, it has to passively face the risk because of the fluctuations of international energy prices. However, China's oil supply risk associated with supply disruption coming from the dependence on specific countries can be improved by diversifying sources of energy imports [13]. Thus, this paper attempts to measure the external oil supply risk from the perspective of diversification of sources, which is of great significance for enhancement of the understanding of the relationship between import risk and diversification of oil suppliers.

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[1] According the oil consumption and production projected in the International Energy Outlook 2013. China's oil import dependency will keep growing and surpass 60% after 2015.

[2] This file is released by China's State Council in January 1, 2013 and can be found in the website of the Central People's Government of the People's Republic of China, http://www.gov.cn/zwgk/2013-01/23/content_2318554.htm.

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The concept of diversification first came from financial markets and is often portrayed by the expression: "Don't put all your eggs in one basket" [14]. Till now, it has been widely used in energy field [15–25]. That is, diversification is an indispensable choice to enhance the security of external oil supply by reducing excessive dependence on a single supplier. In other words, diversification refers to supplier diversification, i.e. a mix of state providers [26]. The Hirschman-Herfindahl index (HHI), initially developed by Hirschman [27] and Herfindahl [28] to measure market concentration, is widely used in energy filed to assess energy diversification or supplier diversification , such as the overall energy security assessment in Taiwan and EU, oil import risk in China and Japan [5,10,24,29]. Therefore, the HHI is adopted in this paper to measure oil import diversification. In previous studies, although the assessment of energy security based on HHI differs to some extent, most generally are conducted by using the price and volume information of oil imports. This is taken as the micro risk of oil supply, while the country portfolio can offer macro risk perspective to optimize sources of oil imports for decision makers [12].

Some related studies have paid attention to the macro supply risk which may come from the overall risk of a given oil supplier [6–8,24,28,29]. For example, economic and socio-political instability can influence the security of external oil supply. The instabilities mentioned above are, basically, components of country risk in oil-exporting regions which a few researchers have addressed [12,30,31]. In addition, it can be deduced from the previous work that potential exports capacity of each oil supplier is another important risk factor of oil suppliers that affects oil-importing nations [32] and [33]. Prompted by these instructive studies, this paper tries to introduce two risk factors, country risk and potential exports capacity into the diversification index because they affect the stability and availability of oil supply.

The potential exports capacity reflects a supplier's oil resources, oil production capacity and export policies and are directly related to the physical availability of oil for importers. With global limited oil resources and the continuing rapid increase of consumption, conventional oil is approaching a peak production and the number of net-exporting countries will be reduced [34–40]. Establishing stable trade relationships with oil suppliers having high potential exports can effectively ensure long-term stability of oil imports. On the contrary, relying heavily on small oil suppliers implies additional risk of need for switching to other suppliers. With the depletion of oil resources, a number of small oil suppliers are beginning to reduce oil exports or have even become oil-importing countries, so some oil-importing countries have to find new oil suppliers to make up for the decrease in imports from those partners. So the resource availability is also a critical factor in energy security. Jansen et al. [32] consider resource depletion as an indicator of long-term energy supply security and Blyth and Lefevre [33] argue that the potential exports of each supplier is a key factor when taking account of the potential for importers to switch suppliers. As a result, potential exports of each supplier should be reflected in oil import diversification. However, only a few researches have taken this into consideration.

In this paper, firstly, potential oil exporting capacity and country risk of each supplier are introduced in the diversification index and then the external oil supply risk indexes are constructed by combining oil dependency with the modified diversification index to measure the security of external oil supply. Evaluation of oil supply security in extant research has largely focused upon individual countries, such as China [5], Japan [10] and South Africa [11], while Vivoda [41] has qualitatively analyzed oil imports diversification in China, Japan and United States. The empirical research in this paper covers the top four oil consuming economies, European Union, United States, China and Japan, which together accounted for two-third of global crude oil imports by volume in 2010[3]. By comparing the differences in oil imports diversification policy and the security of external oil supply of the four oil consuming economies, some good suggestions can be presented for China to ensure its oil supply security in the future.

The structure of the paper is as follows. In Section 2, we present the methodology to modify the traditional HHI and construct four external oil supply risk indexes. The data used in the analysis are described in Section 3. In Section 4, we apply the indexes on China, Japan, the US and EU. Finally, our main findings and policy suggestions are described in the last section as conclusions.

2. Methodology

In this section, firstly, considering all suppliers as the same, traditional oil import diversification index calculated by the HHI is presented, and then taking account of differences in oil suppliers' country risks or potential exports, three modified diversification indexes are proposed. At last, based on the four kinds of diversification indexes, oil import dependency is introduced to construct the external oil supply risk index (OSRI).

2.1. Modifying oil import diversification index

In this section, firstly, we present the traditional oil import diversification index calculated by the HHI when treating all suppliers as the same, and then two modified diversification indexes are illustrated by considering the differences between suppliers in terms of only one aspect, country risk or potential oil exports. Thirdly, considering differences between oil suppliers' country risk and potential oil exports, the fourth modified diversification index is presented.

2.1.1. The traditional oil import diversification index (HHI)

To calculate the degree of concentration, the HHI is the square of summation of market share of each company in the industry [42]. When the HHI is adopted for analysis of oil import diversification, this index is computed as follows:

$$\mathrm{HHI}_i = \sum_{j=1}^{N} w_{ij}^2 \tag{1}$$

where HHI_i is the traditional oil import diversification index, w_{ij} represents the share of supplier j in total oil imports of country i, and is computed by $w_{ij} = x_{ij}/\sum_j x_{ij}$, x_{ij} represents oil imports of country i from supplier j. N stands for the number of total oil suppliers of country i. The value of HHI_i index depends on both inequality of share in oil imports from different countries and the number of oil suppliers. The HHI_i index takes a maximum value of 1 when a country imports oil from only one supplier and a minimum value of $1/N$ when a country imports the same amount of oil from N suppliers. The higher the value of the HHI_i index, the lower is the degree of oil import diversification.

2.1.2. Modified oil import diversification index with country risk (HHI-CR)

There is no easy way to quantify risk associated with an oil supplier; a common practice in the existing literature is to proxy it by a broader measure of country risk. The composite country risk ratings, computed by the Political Risk Services Group (the PRS Group) on a comparable basis and reported in the International

[3] According the statistical data by EIA, http://www.eia.gov/.