Sino-Russian Oil Security: Evolution and Structure

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Abstract. Sino-Russian oil cooperation is of great significance to Sino-Russian oil security. This research evaluates the evolution pattern of China’s external oil supply risk and Russia’s export risk in 2005-2016 and the impact of Sino-Russian oil cooperation on Sino-Russian oil security. It was obtained: The concentration degree of China’s oil import is gradually decreasing, Russia plays an important role in balancing China’s external oil supply and reducing its concentration. When bringing in oil export potential (OEP), China’s external oil supply risk shows the trend of wavy increase, and the continued declining OEP of Russia increases the risk in a certain degree. When bringing in oil price (OP), China’s external oil risk shows an M-style decrease, and the sanction against Russia by western countries led to cliff drop of OP, which led to sharp fall of risk in the short term. The concentration degree of Russia’s oil export shows a wavy increase. The increasingly important role of China in the Russian oil export market (OEM)exacerbates the concentration degree. When bringing in oil import potential (OIP), Russia’s oil export risk shows an M-style increase, and the positive effect of China's exuberant OIP has largely counterbalanced the negative effect of the continued declining OIP of other major Russian oil export markets. When bringing in OP, Russia’s oil export risk shows an M-style increase, especially under the sharp fall of OP in recent years, the risk increases dramatically.

1. Introduction

Oil resources is the primary energy as well as strategic resource in the world, which plays an important role in regional energy security, economic security and even national security [1-3]. With the rapid economic growth, China has become the world's second largest oil consumer and largest oil importer. However, for a long time, about 60% of China’s imported oil is from the Middle East and West Africa [4]. China’s oil import sources (OIS) are too concentrated. Meanwhile, the geopolitical environment in above areas is complicated, which has become a major potential risk factor that restricts China’s external oil supply security. Therefore, Chinese government has been implementing the strategy of diversification on oil import, and oil cooperation with Russia is an important part in this strategy [5]. Russia is an energy superpower and one of most leading energy exporters in the world. However, more than 60% of its exported oil are exporting to Europe, the highly concentrated oil export market (OEM) and complicated Russia-European relationship are direct factors that restrict Russia’s oil export security. Therefore, strengthening energy cooperation with the Asia Pacific region, especially with China, has become an important strategy for Russia to improve its energy security [4] The energy strategy of China and Russia are highly compatible, with the promotion of the two government, the traded volume of oil has been increasing rapidly. In 2016, the volume of oil that China imported from Russia exceeded 50 Mts., Russia overtook Saudi Arabia and became China's largest oil supplier, meanwhile, China became
Russia’s second largest OEM in addition to Netherlands. Sino-Russia oil cooperation has achieved remarkable progress.

At present, existing research mainly study Sino-Russian oil cooperation from the qualitative perspective [4, 6-8], few studies analyzed the impact of Sino-Russian oil cooperation on Sino-Russian oil security from the quantitative perspective, resulting in lack of objectivity and scientific city of existing results. Therefore, in order to meet above deficiencies, based on HHI and definition of energy security, we scientifically evaluate the evolution pattern of Sino-Russian oil security, and the impact of Sino-Russian oil cooperation on it, which can provide theoretical guidance and scientific support for promoting Sino-Russian oil cooperation.

2. Models and methods
Most scholars define energy security from the perspective of energy supply and energy use [9-11], little attention is given to the energy export security. However, for energy exporters, such as Russia, energy export security is also a crucial factor to its energy security and economic security. Therefore, we believe energy security should be divided into energy supply security of energy importers and energy export security of energy exporters, thus we established the external oil supply risk index for importers and oil export risk index for exporters.

2.1. The external oil supply risk index
HHI is the most widely used index to evaluate energy security, it is based on the principle of diversity [12]. Generally, the more diverse the energy import sources or energy export markets, the smaller the HHI, the higher the energy security. HHI represents energy security risk index of region \( r \), \( w_{ij} \) indicates the share of energy region \( r \) import from or export to region \( j \) to its total imports or exports (equation (1) and (2)), showing the distribution of OIS or OEM.

\[
HHI_i = \sum_{j=1}^{n} w_{ij}^2 \\
w_{ij} = \frac{EI_{ij}}{EI_i} \text{ or } w_{ij} = \frac{EE_{ij}}{EE_i}
\]

For oil importers, the distribution of OIS, their corresponding oil export potential (OEP), and oil price (OP) are critical factors that directly affect their external oil supply security. The more diverse of OIS, the greater of OEP and the lower OP, the smaller the external oil supply risk. Therefore, based on HHI, we bring in the factor of OEP and OP into the external oil supply risk index. OEP is indicated by the share of OIS’s proven oil reserve to the world proven oil reserve (SPR), and its reserve and production ratio (RPR). OP is indicated by international annual average oil price. \( i = 1 \ldots m \), which indicates China’s OIS.

\[
HHI_C = \sum_{i=1}^{m} w_{Ci}^2
\]

\[
HHI_C - OEP = \sum_{i=1}^{m} w_{Ci}^2 \times \frac{1}{OEP_i} = \sum_{i=1}^{m} w_{Ci}^2 \times \frac{1}{SPR_i} \times \frac{1}{RPR_i}
\]

\[
HHI_C - OEP - OP = \left( \sum_{i=1}^{m} w_{Ci}^2 \times \frac{1}{OEP_i} \right) \times OP = \left( \sum_{i=1}^{m} w_{Ci}^2 \times \frac{1}{SPR_i} \times \frac{1}{RPR_i} \right) \times OP
\]
2.2. The oil export risk index

For oil exporters, distribution of OEM, their corresponding oil import potential (OIP) and OP are main influencing factors of their oil export security. OIP is indicated by the volume of oil consumption (OC) and their volume of oil imports (OI). The bigger OC, OI, OP, the smaller oil export risk. \( j = 1 \ldots n \), indicates Russia’s OEM.

\[
HHI_R = \sum_{j=1}^{n} w_{Rj}^2
\]  

\[
HHI_R - OIP = \sum_{j=1}^{n} w_{Rj}^2 \times \frac{1}{OIP_j} = \sum_{j=1}^{n} w_{Rj}^2 \times \frac{1}{OC_j} \times \frac{1}{OI_j}
\]  

\[
HHI_R - OIP - OP = \gamma \sum_{j=1}^{n} w_{Rj}^2 \times \frac{1}{OIP_j} \times \frac{1}{OP} \times \left( \sum_{j=1}^{n} w_{Rj}^2 \times \frac{1}{OC_j} \times \frac{1}{OI_j} \right) \times \frac{1}{OP}
\]

Data of distribution of China’s OIS, Russia’s OEM and their volumes of OI are sourced from UN Comtrade. SPR, RPR of China’s OIS and OC of Russia’s OEM, and OP are sourced from 2006-2017 “BP Statistical Yearbooks”. To evaluate the risk, data needs to be normalized.

3. Results and discussion

3.1. China’s external oil supply risk

3.1.1. China’s external oil supply risk that only includes oil import sources (HHIC). HHIc reached its peak in 2008, and then showed a decreasing trend (figure 1), which indicates that China’s OIS is becoming more and more diverse, China’s external oil supply security is improving. In 2008, share of oil that China imported from Saudi Arabia and Angola reached their peak, which accounted for 20.33% and 16.71% of China’s total oil imports, the excessive concentration of OIS brings huge potential threat to China's external oil supply security. Under China’s strategy of diversification on oil import, China’s main OIS gradually expanded from Middle East and West Africa to regions include Russia, Venezuela, Brazil and other Asia and South American countries (figure 2).

![Figure 1. HHIC in 2005-2016](image-url)
During this period, share of oil that China imported from Russia increased from 6.37% in 2010 to 13.77% in 2016 and Russia become China’s first oil supplier, while that China imported from Saudi Arabia and Angola decreased to 13.39% and 11.47% in 2016. The growing share of Russia, Venezuela and Brazil in China's oil import markets plays an important role in balancing China's OIS, reducing the concentration of China’s OIS and improving China's external oil supply security.

Figure 2. Evolution pattern of distribution of China’s OIS. Note: points in above pictures are countries whose shares in China’s total oil imports are >1%; points that are marked with names are the top 10 OIS of China.
3.1.2. China’s external oil supply risk that includes oil import sources and oil export potential (HHI\textsubscript{C-OEP}). In 2005-2016, HHI\textsubscript{C-OEP} shows a wavy upward trend, indicating that the export potential of OIS has an important impact on China’s external oil supply security (figure 3). During this period, several main OIS of China show a steady or wavy declining trend. For instance, Saudi Arab, whose SPR declined from 19.22% to 15.61%, RPR declined from 75.02 to 59.11; Russia, whose SPR declined from 7.59% to 6.05%, RPR declined from 29.81 to 25.54; In addition, SPR and RPR of Oman, Angola and Kuwait all show a wavy declining trend, thus leading to an increasing trend of HHI\textsubscript{C-PE}. It should be noted that with the increasingly important role of Russia in China's oil import market, Russia’s decreasing OEP will directly influence China’s external oil supply security.

![Figure 3. HHI\textsubscript{C-OEP} in 2005-2016](image)

3.1.3. China’s external oil supply risk that include soil import sources, oil export potential and oil price. (HHI\textsubscript{C-OEP-OP}). HHI\textsubscript{C-PE-OP} shows an M-style trend, the overall fluctuation is dramatic (figure 4). OP has a great impact on China’s external oil supply security. In 2005-2016, OP fluctuated dramatically (figure 5), thus leading to the dramatic fluctuation of HHI\textsubscript{C-OEP-OP}. According to the evolution of OP, before 2008, OP increased rapidly from $67 a barrel to $108.42 a barrel, however, the outbreak of financial crisis in 2008 led to a severe oversupply of oil in international oil market and OP presented a cliff fall, which dropped from $108.42 a barrel to $68.99 a barrel in 2009, leading to dramatic decrease of HHI\textsubscript{C-OP-OP}. Along with the recovery of the world economy, the demand for oil gradually resumed, the huge shortage of oil supply led to a rapid rebound of OP, in 2011, OP rose to $118.71 a barrel, which exceeded that in 2008. The rapid rise of OP increased the cost and difficulty for China to import oil, causing HHI\textsubscript{C-OEP-OP} to rise rapidly. However, due to slowdown of worldwide economy, the shale gas revolution and the increase of oil supply in major oil exporters, especially the sanctions against Russia by the western countries because of the Crimea incident in 2014, OP fell dramatically and successively to $43.73 a barrel. The rapid declination of OP greatly reduced HHI\textsubscript{C-OEP-OP} in the short term.

3.2. Russia’s oil export risk

3.2.1. Russia’s oil export risk that only include oil export markets (HHI\textsubscript{R}). HHI\textsubscript{R} firstly express an upward trend before 2010, then a wavy downward to 2013, and an upward again (figure 6).

Before 2010, Russia’s oil exports showed a trend of concentration (figure 7), though number of Russia’s main OEM did not change very much, but their total share increased from 55.24% to 59.01%. Share of exported oil to Netherlands increased from 17.37% in 2005 to 24.74% in 2010. The concentration of Russia’s OEM led to the increase of HHI\textsubscript{R}. In 2011, share that Russia exported to Netherlands dropped sharply to 18.98%, and then increased to 21.11% in 2012, and dropped again to 18.29% in 2013. The change of Russia’s export to Netherlands leads to the wavy trend of HHI\textsubscript{R} in 2011-2013. However, after 2014, Russia’s OEM once again shows a concentrated trend. Oil Russia
exported to China increased rapidly, the share of exported oil to China increased from 9.73% in 2013 to 18.68% in 2016, China become Russia’s second OEM. The rapidly growing share of China in Russia’s OEM intensifies the concentration of Russian oil exports and leads to increase of $\text{HHI}_R$.

3.2.2. Russia’s oil export risk index that include soil export market sand oil import potential ($\text{HHI}_R$-$\text{OIP}$).

$\text{HHI}_R$-$\text{OIP}$ shows an M-style trend, which reached its peak in 2009 and 2014 respectively, and then started to decline (figure 8). Before 2008, $\text{HHI}_R$-$\text{OIP}$ shows a small but steady increase, which on one hand was due to concentrated trend of Russia’s OEM during this period, on the other is due to the decreasing trend of OIP of Russia’s main OEM. During this time, Russia’s biggest OEM Netherlands, whose OC decreased from 50.06 Mts. to 47.29 Mts., OI decreased from 62.15 Mts. to 58.48 Mts., OC and OI of Italy and Germany decreased from 86.67 Mts. and 89 Mts., 124 Mts. and 112 Mts. to 80.38 Mts. and 84.34 Mts., 118 Mts. and 106 Mts. In 2008, affected by the financial crisis, the demand for energy greatly reduced. OC and OI of Netherlands, Italy and Germany reduced to 45.91 Mts. and 35.08 Mts., 75.11 Mts. and 76.01 Mts., 114 Mts. and 97.65 Mts., Netherlands’ OI fell the most, which dropped by 40% compared to that in 2008.
The abrupt drop in OIP led to a sharp rise in Russia’s oil export risk index. After 2009, with the gradual recovery of the world economy, the demand for oil recovered slightly, but under the shale gas revolution, saturation of the world’s oil market and oil overcapacity, the declining trend in Russia’s main OEM failed to change, HHI<sub>R</sub>-OIP shows a decline shortly and then tend to increase again. After 2014, due to the sanction against Russia by the western countries, OP decreased dramatically, which stimulated the oil demand to a certain extent. Russia’s main OEM, such as Netherlands, Italy, Poland, Republic of Korea, etc., their demand for oil started to rebound, OC and OI all tend to increase, OC and OI of Republic of Korea increased from 108 Mts. and 125 Mts. to 125 Mts. and 144 Mts. The rebound of OIP led to downward trend in HHI<sub>R</sub>-OIP.

![Figure 7. Distribution of Russia’s OEM. Note: points in above pictures are countries whose shares in Russia’s total oil exports are >1%; points that are marked with names are the top 10 OEM of Russia](image-url)
During this time, China has played an important role in Russia’s oil export security. In 2005-2016, China has maintained its strong demand for oil, its OC and OI increased from 329 Mts. and 127 Mts. to 579 Mts. and 381 Mts. Oil import from Russia increased from 12.77 Mts. to 52.48 Mts., which accounts for 18.68% of Russia’s total oil exports in 2016. The positive effect of China's exuberant OIP and strong demand on Russian oil has largely counterbalanced the negative effect of the continued declining oil demand of other major Russian OEM, which reduced Russia’s oil export risk and improved Russia's oil export security.

**Figure 8.** \( \text{HHI}_R^{-\text{OIP}} \) in 2005-2016

3.2.3. Russia’s oil export risk index that include oil export markets, oil import potential and oil price (\( \text{HHI}_R^{-\text{OIP}-\text{OP}} \)). OP have a great impact on Russia's oil export security. Before 2008, \( \text{HHI}_R^{-\text{OIP}-\text{OP}} \) showed a slight declining (figure 9), it’s mainly because of the rapid increase in OP in 2005-2008, which rising from $67 a barrel in 2005 to $108.42 a barrel in 2008 (figure 5). The positive effect brought by the rise in OP overtook the negative effect brought by declining OIP, and led to the slight decrease of \( \text{HHI}_R^{-\text{OIP}-\text{OP}} \). However, under the impact of the financial crisis, OP fell sharply, leading to a steep rise in \( \text{HHI}_R^{-\text{OIP}-\text{OP}} \). In 2010-2011, though OP rebound, the positive effect of rebound of OP was partly counteracted with the negative effect of the decline in OIP of Russia’s OEM, therefore, \( \text{HHI}_R^{-\text{OIP}-\text{OP}} \) did not fluctuate obviously in this period. However, after 2011, along with the new round of fall in OP, especially under the sanction against Russia by the western countries, OP fell dramatically, which greatly increased \( \text{HHI}_R^{-\text{OIP}-\text{OP}} \). The positive effect brought by the recovery of OIP of Russia’ OEM in 2015 was fully overwhelmed by the negative effect brought by the dramatical fell in OP. As a result, \( \text{HHI}_R^{-\text{OIP}-\text{OP}} \) did not stop to increase until 2016.

**Figure 9.** \( \text{HHI}_R^{-\text{OIP}-\text{OP}} \) in 2005-2016
4. Conclusion
We analyzed the evolution trend of China’s external oil supply risk and Russia’s export risk in 2005-2016, and the impact of Sino-Russian oil cooperation on Sino-Russian oil security. It was observed that: China’s OIS tend to be diverse, and Russia plays an important role in balancing China’s external oil supply and reducing its concentration. HHI_{C-OIP} shows a trend of wavy increase due to the declining trend of SPR and RPR of China’s main oil supplier. Along with the increasingly important role of Russia in China’s oil import market, the continued declining OEP of Russia increases HHI_{C-OEP} and reduces China's oil supply security in a certain degree. HHI_{C-OEP-OP} shows an M-style decrease, OP is vital to China’s external oil supply security. And the sanction against Russia by western countries led to cliff drop of OP, which led to sharp fall of HHI_{C-OEP-OP} in the short term.

The concentration degree of Russia’s OEM shows a wavy trend. The increasingly important role of China in the Russian OEM intensifies the concentration of Russia’s OEM, which increases HHI_{R}. Affected by the declining trend of OIP of Russia’s main OEM, HHI_{R-OIP} shows an M-style increase, but the positive effect of China’s exuberant OIP has largely counterbalanced the negative effect of the continued declining OIP of the other major Russia’s OEM. HHI_{R-OIP-OP} shows an M-style increase, affected by the sharp fall of OP in recent years, HHI_{R-OIP-OP} has risen rapidly.

Acknowledgment
National Natural Science Foundation of China (No. 41701639, No. 41911530103), Russian Foundation for Basic Research (No. 19-55-53026).

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