Advance Journal of Food Science and Technology 8(12): 853-860, 2015
DOI:10.19026/ajfst.8. 2719
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: January 20, 2015 Accepted: January 31, 2015 Published: July 20, 2015

Research Article

Risk Assessment and Analysis of Diversification of China's Round Wood Import

[1]Cheng Baodong, [2]Diao Gang, [1]Li Tingting and [1]Yu Chang
[1]School of Economics and Management, Beijing Forestry University, China
[2]School of Business, Hebei Agriculture University, China

Abstract: With China's economic and social development, China's demand for timber keeps increasing and China's dependence on round wood import remains high. In this study, the risk change of China's round wood import was examined in two perspectives, which were the risk and the diversification of China's round wood import. The study also discussed how to optimize the import structure using quadratic model. Optimization results suggested that import diversification was an important way to reduce the risk of round wood import; China shall adjust its sources of imports to reduce the risk.

Keywords: Import diversification, quadratic model, risk assessment, round wood import

INTRODUCTION

With China's economic growth, the demand for timber maintains a rapid growth rate. According to the State Forestry Administration's prediction, China's timber consumption is about 500 million m^3 in 2013; timber consumption in 2020 is expected to reach 800 million m^3. From the data we can know that China is still in great demand of timber. Figure 1 depicts China's round wood production and import from 2000 to 2012, China's round wood import keeps an upward trend and after 2000, China's dependence of round wood import has been rising. In addition, the supply problem will not only affect China's economic and social development, but also relates to the environmental issues. If the round wood import is affected, then the logging amount of the domestic forests will be increased, which will weaken the protection of the ecological functions of forest resources and thus threaten the sustainable use of forest resources. Therefore, how to effectively maintain the stability and risk diversification of round wood import is an important issue of China's timber supply.

Current researches of China's round wood import mainly concentrates on the domestic influential factors (Zhang *et al*., 2011), structure of round wood import (Yang and Nie, 2008), legal requirements on round wood import (Zeng *et al*., 2012), international illegal timber logging (Wenming, 2009) and so on. None of them has ever reached the field of risk assessment of round wood import. In order to study the round wood import risk, this paper will build the China's round wood import safety index based on the diversification index and the oil supply safety comprehensive index.

Researches on energy imports' safety and risk often apply indexes, which are commonly based on the diversification index. Some of these indexes only analyze one of the supply safety issues; some complex indexes analyze multiple factors of the supply safety issues (Kruyt *et al*., 2009). Simple indexes are important tools for analyzing supply safety and risk and these simple indexes can become complex indexes through an appropriate combination. Commonly used simple safety indexes are: Resource Stock volume (USGE, 2000), R/P Index (Feygin and Satkin, 2004), Diversity Index (Jansen *et al*., 2004; Asia Pacific Energy Research Centre (APERC), 2007) and so on. Currently, Shannon-Weiner Index (SWI) and Herfindhal-Hirschman Index (HHI) have been widely used in researches, such as Grubb *et al*. (2005) applied SWI in the study of the diversification of energy

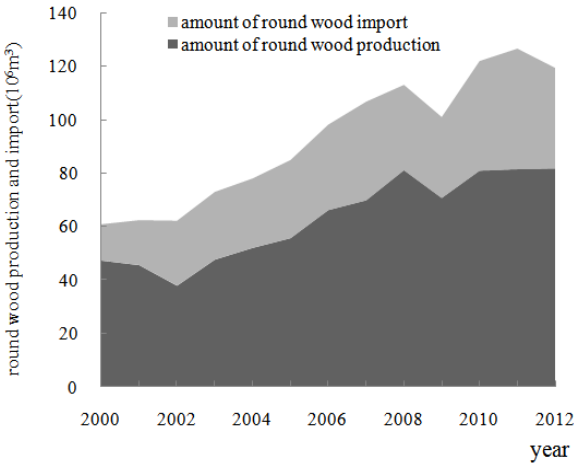

Fig. 1: Amount of round wood production and import of China (FAO forestry databases)

Corresponding Author: Cheng Baodong, School of Economics and Management, Beijing Forestry University, China

supply, Neff (1997) applied HHI in the study of the energy supply source issues. Complex indexes of energy supply safety can better reflect the risks that exist in the supply and such complex indexes are generally based on simple indexes, especially SWI and HHI. For instance, Jansen *et al*. (2004) based SWI as the core, adding political risk and resource risk on the base of the degree of market concentration, IEA (2007) has a similar study. Energy import risk and timber import risk share many features. Same as crude oil, timber is also one of the most important resources and materials in the economic development and the safety supply of these resources will influence the economic and social development. Imports of crude oil and timber both are affected by resource stock volume and the exploration cycle is long. Thus they are more susceptible to the political, economic and trade policies of the exporting countries. Therefore, we can draw on the energy import risk index and build the round wood import risk index to analyze the import diversification.

China's round wood import risk index and the establishment of the optimization model of the timber import structure: In this part, China's round wood import risk index is built on the basis of oil supply safety index. Then optimization model of the timber import structure is built on the basis of China's round wood import risk index.

China's round wood import risk index: HHI is widely used to measure the diversification. In Economics, HHI is often used for measuring market concentration. In the research of diversification, HHI is used to measure the concentration of the source of import (Stirling, 2007). HHI is the square sum of the ratio of the amount of import from the resource-exporting-countries to total import Eq. (1); the larger the HHI, the higher the concentration.
Herfindahl-Hirschman Index:

$$HHI = \sum_{i=1}^{n} \left(\frac{x_i}{x} \right)^2 \quad (1)$$

Many existing studies built composite risk index on the basis of HHI, composite risk index reflects not only the degree of concentration of the source of import, but also measures external risks. The factors that frequently added in the composite index are as follows: political risk, oil reserves, trade distance between countries. This paper measures China's round wood import risk from three perspectives: political risk, trading risk and resource sustainability.

Political risk is the most important factor affecting the stability of import, such as Jansen *et al*. (2004) constructed a complex index, the first part added political risk based on SWI. The study of the IEA (International Energy Agency) (2007), also added political risk on the basis of HHI index. For round wood import, the political risk of the exporting country is an important factor in China's round wood import. The greater the political risk, the more uncertain factors to China's round wood import Eq. (2).
Political risks:

$$PR = \left[\sum_i \left(\frac{NPI_i}{NPI} \right)^2 r_i \cdot p_i \right] \cdot s \quad (2)$$

where,
NPI_i = The amount of round wood imported from country i to China
NPI = The aggregate amount of round wood imported by China
r_i = Political risk of country i
p_i = The proportion of country i's round wood export amount to the total output
s = China's dependence rate on round wood' import

In the course of round wood trade, there are many other factors also affect the safety of import, degree of trading freedom and the distance between timber-exporting country with China are two relative important factors. In the Coq and Paltseva (2009) study, they applied index variable to divide the distance between timber-exporting-country with China into three levels. Based on this, we add the freedom degree of the timber-exporting-country, together with the distance between two countries and whether we share border with the timber-exporting-country, to measure the trading distance Eq. (3).
Trading risk:

$$IR = \left[\sum_i \left(\frac{NPI_i}{NPI} \right)^2 \cdot t_i \cdot d_i \cdot b_i \cdot p_i \right] \cdot s \quad (3)$$

t_i = Freedom degree of the timber-exporting-country

Distance between countries:

$$d_i = \frac{dis_i}{\max(dis)} \times 100 \quad (4)$$

where dis = $[dis_1 \ldots dis_n]_{1\times n}$ is the distance vector between timber-exporting-country to China.

Whether we share border with timber-exporting country:

$$b_i = \begin{cases} 1, countries\ that\ share\ borders\ with\ China \\ 2, other\ \ countries \end{cases} \quad (5)$$

In the energy supply safety research, the stock volume of energy and yield ratio is an important measurement of persistent resource supply (Greene *et al*., 2005; Mulders *et al*., 2006); the stock volume here refers to the aggregate amount of the discovered

oil. There is a close connection between round wood's supply with the forest resources stock volume. Thus, the supply sustainability can be reflected by the ratio of forest stock volume to round wood production Eq. (6).
Resource sustainability risk:

$$RR = \left[\sum_i \left(\frac{NPI_i}{NPI} \right)^2 RP_i \right] \cdot s \tag{6}$$

RP_i = Ratio of forest stock volume to round wood production (R_i/P_i, R is the forest stock volume of country i, P is the total output of country i's round wood). The higher the R/P index, the stronger the sustainability of the supply in the long term. To keep the trends consistent with other indexes, the study uses the reciprocal of the R/P index as the assessment of the forest resources risk.
China's round wood import risk index:

$$TR = PR + IR + RR \tag{7}$$

Equation (7) is China's round wood import risk index; the round wood import risk consists of three parts: political risk, trading risk and resource risk.

Optimization model of the round wood import structure: Through the observation of the round wood import risk index, we can see that NPI_i^f is the only variable and all the other variables are exogenous variables determined by the features of the timber-exporting-country. So we can adjust the size of the NPI to reduce the overall risk of import. In addition, in the round wood import risk index, NPI is quadratic term; we can transfer the timber import risk index into matrix form.

The column vector of the amount of round wood imported from each timber-exporting-country to China: $x = [NPI_1, NPI_2 \ldots NPI_n]'$, n is the number of the timber-exporting-countries.
Coefficient matrix:

$$A = \begin{bmatrix} \frac{[r_1 + t_1 \cdot d_1 \cdot b_1 + RP_1] p_1 s}{(NPI)^2} & & \\ & \ddots & \\ & & \frac{[r_n + t_n \cdot d_n \cdot b_n + RP_n] p_n s}{(NPI)^2} \end{bmatrix} \tag{8}$$

China's round wood import risk index is transferred into:

$$TR = x'Ax \tag{9}$$

Round wood import is bound by two main aspects: the aggregate amount of the round wood imported from the main source country and the total export amount of the source country's round wood.

The constrain of aggregate amount of the round wood imported from the main source country to China:

$$x' \cdot I = \mathrm{NPT} \tag{10}$$

where,
I = A column vector, in which all n-dimensional column is 1
NPT = The total amount of round wood imported from main source country to China

Condition for the amount of round wood imported from the source country to China:

$$NPI_{\min} \le x \le NPI_{\max} \tag{11}$$

where, NPI_{min} and NPI_{max} are the lower limit and upper limit of the round wood import. They are determined by the ration of total export amount to the upper and lower limit.

Lower limit of round wood from the main source country of import:

$$NPI_{\min} = lb \times EX_t \tag{12}$$

Upper limit of round wood from the main source country of import:

$$NPI_{\max} = ub \times EX_t \tag{13}$$

$EX_{n\times 1}$ is the vector of each timber-exporting-country's total round wood export during period t, $lb_{n\times 1}$ and $ub_{n\times 1}$ are the proportional vectors of the upper and lower limit of amount of timber from the main source country of round wood to China and $0 \le lb < ub \le 1$.

Therefore, the minimum import risk issue can be transferred into the following quadratic model:

$$\min x'Ax \quad s.t. \begin{cases} X' \cdot I = NPT \\ NPI_{\min} \le x \le NPI_{\max} \end{cases} \tag{14}$$

By solving quadratic programming problem through Eq. (14), we can calculate each country's round wood export amount to China when it is at the minimum supply risk.

This study focuses on the analysis of two cases: limits and no limit of the main source country of round wood to China. The no limit situation refers to that each country's round wood export quantity to China can reach its total export quantity or China can also import no round wood from the country; the limits situation refers to that the export volume from each country is between the minimum volume and the maximum volume over the years.

Table 1: Main sources of timber imports of China

	High risk (1-25)	Medium risk (26-50)	Low risk (51-75)	Ultra-low risk (76-100)
Africa	Central Africa	Cameroon[b]	Gabon[b]	
	Congo[b]	Madagascar	Mozambique[b]	
	Guinea	Tanzania		
		Equatorial Guinea		
		South Africa[b]		
Europe	Russia[a, b]	Romania	Belgium	Germany[b]
			France[b]	Denmark
				Netherlands[b]
				Slovakia[b]
Asia	Indonesia[a, b]	Laos[a]	Malaysia[a, b]	
			North Korea[a]	
	Myanmar[a, b]	Thailand[a]	Vietnam[a]	
America				Canada[b]
		Guyana		U.S.[b]
Oceania				Australia[b]
	Papua New Guinea[b]	Solomon Islands		New Zealand[b]

[a]: Countries that share borders with China; [b]: Countries whose round wood export amount rank into top 30; The degree of political stability adapts the mean value from 2000 to 2012

Constraint 1: lb = [0…0], ub = [1…1], this constraint sets no limit for round wood export from source country to China; each country's round wood export quantity to China can reach its total export quantity. Therefore, the constraint conditions are relatively broad and it is the smallest risk after optimization.

Constraint 2: $lb_{n\times1}$ = min (v), $ub_{n\times1}$ = max (v). v is the ratio of total round wood import from source country to China to the aggregate round wood export of the source country. Thus, lb is the minimum vector of the ratio of total round wood import from source country to China to the aggregate round wood export of the source country in different periods and ub is the maximum vector. These constraints determines its upper and lower limit on the basis of the past conditions of China's round wood import, so the constraint is the strongest of all the constraints and it is closest to the actual situation.

Risk assessment and structure optimization of China's round wood import: On the basis of China's round wood import risk index and structure optimization model, this part evaluates the risk of China's round wood import and optimize the structure of round wood import by taking advantage of the structure optimization model.

Data source: During 2000 to 2012, China mainly imported round wood from about 60 countries and Russia is the biggest timber export country to China among them. The study selects 32 main countries (Table 1), which round wood export to China in the amount that contributes more than 95% of the total amount of Chinese round wood import. From the angle of geographic distribution, there are 10 African countries, 8 European countries, 7 Asian countries, 3 American countries and 4 Oceania countries. Viewing from the angle of political stability, there are 7 highly risky countries, 10 medium risky countries and 15 countries that are considered to be less risky. Among these countries, 8 countries share borders with China, with 6 countries adjoin China with land; the other 2 adjoin China with sea. Eighteen countries of this group rank into the top 50 timer-exporting countries based on the global round wood import amount rating and almost include all top 10 countries of timber export. The data of the amount of timber imports (HS code 4403) from these 32 countries to China comes from UN Comtrade Database (2013), the date of round wood production of export countries comes from FAO Database (FAO, 2013).

There are many risk rating agencies and international organizations evaluating the risk of sovereign state and the outcome of evaluation becomes the basis for multinational investment. Among them, the most famous are Standard and Poor, Moody and international risk index data from American PRS and world government index from World Bank. WGI (Worldwide Governance Indicators), which includes risk status of 215 economic entities from 1996 to 2012. The index includes the degree of political stability, government efficiency and controlling corruption capability. Due to the fact that WGI index is more comprehensive than any other indexes in terms of targeted countries and districts, the dissertation therefore adapt WGI, so we use the WGI to measure the political risk of China's timber import. During the process of calculation, we evaluate risk status of timber export countries only on the basis of degree of their political stability. Because of the opposite variation trend of WGI with the HHI, the paper transfers WGI index in the way as Eq. (15) shows.

WGI index transfer:

$$r_i = 100 - WGI_i \tag{15}$$

The data of market openness of supply risk index comes from economic openness data base of Heritage (2013). Because of the opposite variation trend of

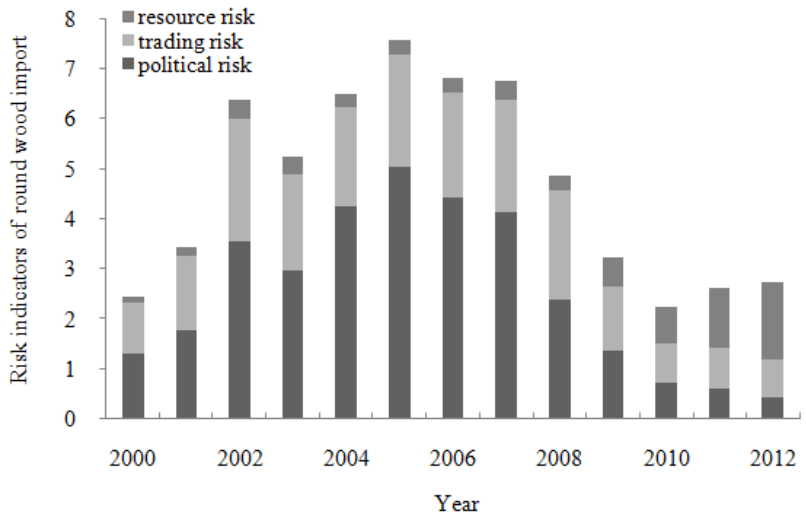

Fig. 2: Risk indicators of round wood import

market openness when compared with HHI, this paper alters WGI in the way as Eq. (15) shows. In this study, the distance between countries adopts the weighted distance calculated by CEPPII (2006). The weighted distance of city groups in future calculates the distance between city groups. Besides, the date of forest area and stock volume come SOFO (State of the World's Forests). Each country' forest stock volume is calculated by multiplying forest area by stock volume per unit area.

Risk of China's round wood import: Because the simple diversification index cannot effectively reflect the trends of supply safety, this section evaluates China's round wood import safety through calculating the China's round wood import risk index (Fig. 2). The evaluation results illustrate the political risk for China's round wood import experienced a fall after rise and after 2010; it has the smallest percentage of the total risk. Not many changes in the trading risk, for the sake of the overall increasing of trading freedom of each exporting country, trading risk is gradually decreasing in the percentage. Little change in the magnitude of trade risk, but the decrease rate is lower than the political risk. Before 2008, the risk of forest resources accounted for a small proportion in the risk and was not a major factor affecting the risk. But after 2008, the increasing of resource risk leads to the rising of resource import risk showing a new upward trend.

China's round wood risk fluctuations process is mainly caused by the round wood import reduction from Russia. After 2007, Russia increased the tariffs on round wood export, resulting in the proportion of round wood imported from Russia to China fell from 43 to 30%, thereby enabling the increase of the round wood import from Australia, Canada, Papua New Guinea, Solomon Islands, New Zealand, the United States. Meanwhile, the developed countries strengthen the protection of forest resources, such as the United States developed the Lacey Act, the EU issued FLEGT, the implementation of these policies increased China's concern to the legitimacy of the timber import. In order to avoid the influence from the above policies, China's round wood import from developed countries shares a rapid growth. Since Australia, Canada, the United States and New Zealand, these developed countries have relatively low political risk, the political risk of China's round wood import achieve rapid decline after the peak. Meanwhile, Australia, Canada, the United States and New Zealand have a high degree of trade freedom and therefore the trading risk shows a downward trend after reaching the peak.

The only rising risk factor is the sustainability of the resource and it is mainly because the continuing reduction in the world's forest areas, leading to the decline in supply capacity, thereby causing an increase in the sustainability risk of resources. Sustainability risk will not affect China greatly in the short term, but in the long term, it will become the most important factor for China's round wood import. With the decline in the quantity of forest resources, the resource risk will be the main risk faced by China's round wood import. Also, the Chinese round wood import will be faced with political and environmental risks derived from the resource risk. For example, China's round wood trade issue will be politicized; some countries and international organizations proposed arguments like "China's Wood Black Hole "and" Chinese Output Ecological Crisis".

Structure optimization results of China's timber import: This study will use MATLAB to repeat solving quadratic programming problems and you will get the minimum import risk of every year during 2000 to 2012 and the optimal exporting quantity from each country to China.

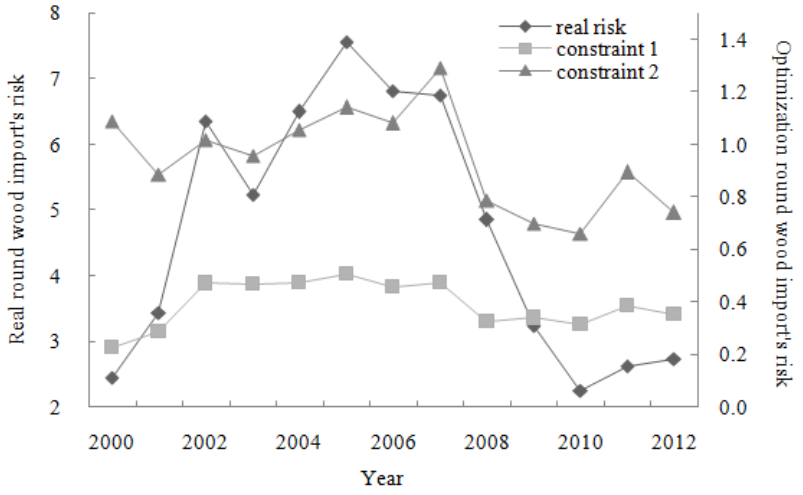

Fig. 3: Comparison of round wood import's risk indicators between real and optimization

Table 2: Average ratio of round wood export to China from different countries and import of China constraints of a real situation of the country the difference between two difference constraints

Country	Actual status (%)	Constraint 1 (%)	Balance (%)	Constraint 2 (%)	Balance (%)
Australia	1.6	4.4	2.8	3.9	2.3
Belgium	0.3	3.4	3.2	0.7	0.4
Cameroon	0.8	1.2	0.4	1.1	0.3
Canada	1.5	10.3	8.7	5.7	4.2
Central Africa	0.1	0.6	0.5	0.5	0.4
Congo	1.2	2.2	1.0	1.9	0.7
North Korea	0.3	0.4	0.0	0.4	0.0
Denmark	0.1	2.1	2.0	0.4	0.3
Equatorial Guinea	1.3	1.3	0.0	1.4	0.1
France	0.6	7.6	7.0	1.7	1.1
Gabon	3.4	2.5	-0.9	3.9	0.4
Germany	1.5	5.3	3.8	1.9	0.4
Guinea	0.1	0.1	0.1	0.1	0.1
Guyana	0.1	0.3	0.2	0.2	0.1
Indonesia	1.0	2.3	1.2	1.5	0.4
Laos	0.1	0.7	0.5	0.4	0.3
Madagascar	0.0	0.1	0.1	0.1	0.1
Malaysia	6.1	12.8	6.7	8.1	2.0
Mozambique	0.4	0.5	0.0	0.5	0.0
Myanmar	2.6	5.1	2.5	3.8	1.2
Netherlands	0.0	1.6	1.6	0.1	0.1
New Zealand	8.9	3.1	-5.8	7.2	-1.7
Papu New Guinea	6.1	3.6	-2.4	6.3	0.2
Romania	0.2	0.9	0.7	0.5	0.3
Russia	54.0	8.3	-45.7	32.0	-22.0
Slovakia	0.1	5.1	4.9	0.3	0.2
Solomon Islands	2.6	2.9	0.3	3.5	0.9
South Africa	0.0	0.9	0.9	0.1	0.1
Thailand	0.0	0.0	0.0	0.0	0.0
Tanzania	0.0	0.1	0.1	0.1	0.1
U.S.	2.9	8.5	5.5	9.9	6.9
Vietnam	0.2	0.2	0.0	0.2	0.0

Figure 3 shows the round wood import's risk index in three cases; constraints 1 and 2 are consistent with the risk of changes in actual risk trends. But constraint values 1 and 2 are far less than the actual values and the smaller the constraint range is, the higher the risk. Constraint 1 sets no limit on the import quantity from source countries to China, so the risk can be reduced to its minimum through adjusting the share of each country in a wide range. Constraint 2 determines the constraint range according to the situation of each country's actual export to China from 2000 to 2012. This range narrows the interval of each country's import share, but the overall import risk only accounts for 20% of the actual risk. Ways to optimize the import risk by adjusting the share of exports from each country and the apportioned the share of high risk countries in the actual situation to countries with low risk, in order to achieve the goal to minimize the import risk. In comparison, constraint 1 is relatively the idle one, China can assure any amount of the timber import (less than the gross timber export) from the exporting countries, so the risk of round wood import is the

minimum under constraint 1, not in any other constraints may the risk be smaller. Constraint 2 selects more practical constraint conditions on the basis of historical situation, so the difference between constraint 2 and the actual one is small (Table 2).

As Table 2 shows, the gap between the actual value and the optimization value of imports from Russia, the United States, Canada and New Zealand is big. Due to the high political risk and trading risk in Russia, we avoid the risk in the optimization process in order to reduce round wood import from Russia. Especially in the absence of strong constraints, Russia's round wood export to China is reduced to an average of about 300 million m^3. Under constraint 2, there is a big difference with the actual value before 2010, but in 2010 these two cases are almost exactly the same. This is mainly because the Russia's restriction on round wood export, leading the reduction of China's round wood import from Russia. Same with Russia, New Zealand after optimization, reducing the amount of round wood export to China. Although New Zealand's less risky in the political and trading aspects, but New Zealand's sustainability risk is high, with forest resources in 2012 R/P value of only 11. Therefore, in order to reduce resource risk, the results optimized to reduce the round wood import from New Zealand. After optimization, round wood exports from U.S. and Canadian are significantly improved, especially under constraint 1, the export increases by several times. The political, trading and resource risks of United States and Canada are low, which results in a higher share of import in the optimization process.

CONCLUSION

China's economic and social development results into the increasing demand of timber and the shortage of domestic timber supply, which in turn leads to high level of China's dependence on round wood import. This paper builds up China's round wood import risk index on the basis of oil import risk index. Meanwhile, by setting up the risk index of round wood import as target function, the paper works out the optimal structure of round wood import from 2000 to 2012. According to the outcome of the risk index, because of the restrict of round wood import from Russia and the attached importance of validity of timber from developed countries, China has a decreasing amount of import from Russia, however developed countries headlined by America, New Zealand and etc have a rising amount. Therefore, the extent of the aggregation of Chinese timber declines and the risk at large exerts a trend of falling after 2005. As we can tell from the outcome of optimization structure; diversification is an important way to reduce the risk of import. Under constraint 1, China can import round wood from countries in any amount that is smaller than the country's total amount and this is the minimum risk situation. Under constraint 2, although Chinese amount of round wood import is rigidly restricted, the overall risk of import substantially declines. Thus in face of the increasing timber demand and high level of dependence of import, China shall adjust the sources of round wood import to reduce the risk. Also China needs to reduce the amount of import from Russia to lower the level of dependence to Russia and increase the amount of import from countries like America and Canada. Importing round wood from developed countries could effectively avoid the problem of round wood validity and reduce the overall risk of the import. Meanwhile, in purpose of diversification of round wood import, China should actively expand new sources of round wood import as well.

ACKNOWLEDGMENT

The authors would like to thank for the support of Beijing Higher Education Young Elite Teacher Project (YETP0775) and the support of National Natural Science Foundation of China (712030 11).

REFERENCES

Asia Pacific Energy Research Centre (APERC), 2007. A Quest for Energy Security in the 21st Century. Institute of Energy Economics, Japan. Retrieved form: /www.ieej.or.jp/apercS (Accessed on: August 27, 2007).

CEPPII, 2006. Retrieved form: http://www.cepii.fr/CEPII/en/welcome.asp.

Coq and Paltseva, 2009. Enterprise Dynamic Capability evolution theory and empirical study [D]. Fudan University

FAO, 2013. Retrieved form: http://faostat.fao.org/DesktopDefault.aspx?PageID=626andlang=en#ancor.

Feygin, M. and R. Satkin, 2004. The oil reserves-to-production ratio and its proper interpretation. Nat. Resour. Res., 13(1).

Greene, D.L., J.L. Hopson and J. Li, 2005. Have we run out of oil yet? Oil peaking analysis from an optimist's perspective. Energ. Policy, 34: 515-531.

Grubb *et al*., 2005. Road of the double transformation of Chinese economy [M]. Renmin University of China Press

Heritage, 2013. Retrieved form: http://www.heritage.org/.

IEA, 2007. World Energy Outlook 2007-China and India Insights. International Energy Agency, Paris.

Jansen, J.C., W.G. van Arkel and M.G. Boots, 2004. Designing indicators of long-term energy supply security. ECN-C–04-007, pp: 35.

Kruyt, B., D.P. van Vuuren, H.J.M. de Vries and H. Groenenberg, 2009. Indicators for energy security. Energ. Policy, 37: 2166-2181.

Mulders, F.M.M., J.M.M. Hettelaar and F. van Bergen, 2006. Assessment of the global fossil fuel reserves and resources for TIMER. TNO Built Environment and Geosciences, Report No. 2006-u-R0003/B, Utrecht, The Netherlands.

Neff, T.L., 1997. Improving Energy Security in Pacific Asia: Diversification and Risk Reduction for Fossil and Nuclear Fuels. PARES Project, Center for International Studies, Massachusetts Institute of technology, Cambridge USA.

Stirling, A., 2007. A general framework for analysis diversity in science, technology and society. J. Roy. Soc. Interface, 2: 707-719.

UN Comtrade Database, 2013. Retrieved form: http://comtrade.un.org/.

USGE, 2000. World Petroleum Assessment 2000. Retrieved form:/http://pubs.usgs.gov/fs/fs-062-03/S on 28-2-2008.

Wenming, S.J.L., 2009. Research on the issue international timber illegal logging and associated trade [J]. Forestry Econ., 6: 76-77.

Yang, H.J. and Y. Nie, 2008. Supply and demand structure of china's timber import and timber analysis [J]. World Agr., 8: 53-54.

Zeng, Y., W. Zeng and G. Qin, 2012. Impacts of wood legality trade requirement on Chinese wood product enterprises and its countermeasures-investigations in Jiangsu, Zhejiang and Shandong Provinces [J]. Forestry Econ., 5: 39- 40.

Zhang, L., Z.J. Cai and L.M. Niu, 2011. An analysis of the effects of influencing factors of Chinese timber imports [J]. Issues Forestry Econ., 4: 321-322.