Empirical Analysis of China Carrying out

Forest Carbon-sink Trade Potential

Haiyan Shen[1]，Ping Zhao[2]

1. Department of World Economics, Harbin Institute of Technology，Harbin, Heilongjiang150001,China
2. Department of International Economics and Trade, Harbin Institute of Technology，Harbin,Heilongjiang 150001,China
sdrzshy@126.com

Abstract:Climate warming ranks the top of ten ecological problems that human beings have to face. The greenhouse effect is the root of climate warming, which is formed by over-emission of carbon dioxide (co_2) and other heat-trapping gases. In December of 1997, the 3rd Conference of the United Nations Framework Convention was held in Kyoto, Japan, during which 149 countries signed the "Kyoto Protocol", whose purpose was to limit greenhouse gas emissions of the developed countries to curb global warming. The Kyoto Protocol allowed the developed countries to invest in forest carbon sink project in the developing countries and make forest carbon sink trade so as to receive the reduced co_2 emission amount.

Through the empirical analysis on the trade potential of Chinese forest carbon sinks, it can be found that forest volume per unit area affects Chinese forest carbon sink potential. By 2050, if the forest volume per unit area maintains current level as 84.73 cubic meters/ha, Chinese total forest carbon sink potential will be 8.64×10^9 C, which accounts for 54.34% of existing carbon reserve. What's more, if the forest unit area changes to be the international average volume as 100 cubic meters/ha, Chinese entire forest carbon sink potential will be 13.06×10^9C, which accounts for   82.14% of existing carbon reserve.

Through studying on the trade potential of Chinese forest carbon sinks, we observe that China has potential on the forest carbon sinks trade, moreover, the potential is huge and can be improved. Therefore, China should actively participate in project of international greenhouse gas emission reduction, turn the potential of forest carbon sinks trade into reality, and promote the development of Chinese forestry economic.

1. INTRODUCTION

According to the theoretical analysis, China has the potential to carry out forest carbon-sink trade, but we need empirical research on its specific potential. Now, from the point of analysis on Chinese current forest carbon sink accumulation and prediction of future forest carbon accumulation, this article analyzes the potential that China carries out forest carbon sink trade. This article provides a basis for empirical research for China carrying out forest carbon-sink trade.

2. MODEL DESCRIPTION AND PARAMETERS DETERMINATION

At present, the international and domestic study about measurement methods towards volume of forest carbon sinks mainly have six kinds, including eddy correlation method, biomass method, accumulation method, biomass inventory method, eddy accumulation method of relaxation and chamber method. However, these six methods basically belong to pure natural science category and have two shortages. On one hand, they need field measurements; On the other hand, their

calculation methods are more complicated. From the perspective of social science, we studies the forest carbon sink in order to analyze the potential that China carry out forest carbon-sink trade. If the calculation method is very complicated, it will lose its operability. As a result, according to the practicality and feasibility of calculation method, and on the basic of natural science calculation methods of volume of forest carbon sinks and the study results, this article uses forest expansion method to analysis on potential of forest carbon-sink trade.

2.1 Model Description

Forest accumulation expansion method is basically divided into two parts: first, we calculate the amount of carbon by standing tree biomass as the main body, which needs four steps：calculating on the basis to forest growing stock (stem volume), calculating trees (including branch wood, roots) biomass through accumulation expansion coefficient, calculating dry weights of biomass through bulk density (dry weight coefficients), and calculating carbon sequestration by the rate of carbon.; second, we need to calculate the forests natural carbon sequestration. We can regard

calculating the amount of forest biomass carbon sequestration as the basis, and then calculate forest carbon sequestration according to the proportional relationship between forest biomass carbon sequestration and under storage plant carbon sequestration, and proportional relationship between forest biomass carbon sequestration.

During the survey and statistics of the forest resources, volume of forest resources is the biomass of the trunk tree. In order to calculate the total biomass, volume of forest resources must be calculated by the ratio between the various parts of the biomass. So, we can do further calculation on forest biomass carbon sequestration. The carbon sequestration of wood can be calculated by timber production, what's more, forest carbon sinks consumed in timber production can be estimated by the relationship between logging volume ratio and wood utilization, and the difference between them is carbon dioxide emissions in the forestry production.

Based on the above model description, one model is established based on the first part as follows:

CF= Tree biomass carbon sequestration

$$CF = \sum (S_{ij} \times Cij) \qquad (1)$$

And $\quad C_{ij} = V \times \delta \times \rho \times \gamma$

Where:

S_{ij}——Area of classi forest type in class j district

C_{ij}——Carbon density of biomass of class I forest type in class j district

V_{ij}——Volume per unit area of class i forest type in class j district

δ——Biomass expansion coefficient

ρ——Volumetric coefficient

γ——Carbon rate

The second model is the form established on the basis of the second part as follow:

CF= Trees biomass carbon sequestration+ Forest plants carbon sequestration+ Solid carbon of woodland

$$CF = \sum (S_{ij} \times C_{ij}) + \alpha \sum (S_{ij} \times C_{ij}) + \beta \sum (S_{ij} \times C_{ij}) \, (2)$$

Where:

α—Carbon conversion factors of understory plant

β—Carbon conversion factors of forest

In order to assess the potential of Chinese forest carbon more accurately, this article will use upon models to calculate respectively.

2.2 Parameters Determination

In the calculation of analyzing Chinese forest carbon sinks potential, every parameter in this article will take IPCC default values.

δ -accumulation expand coefficient of forest resources:

Using the coefficient can convert trees volume to biological volume with trees as the main. Internationally general IPCC default value is 1.90.

ρ - the bulk density:

This coefficient's purpose is entirely changing forest biomass accumulation into dry weight conversion factor. Internationally general IPCC default value is 0.50.

γ - carbon content:

This coefficient's purpose is converting biomass dry weight to conversion factor of carbon sequestration. Internationally general IPCC default value is 0.5.

α - carbon conversion factor of understory vegetation:

The function of this coefficient is to calculate carbon sequestration of undergrowth plants (including litter). Internationally general IPCC default value is 0.5.

β - Conversion factor of forest carbon sequestration:

The function of this coefficient is to calculate woodland carbon sequestration. Internationally general IPCC default value is 1.244.

By the way, these parameters are determined by average, whose results basically can meet the needs of macroscopic research in this article. However, using this coefficient to analyze and calculate carbon sequestration of a specific amount forest land may be exist errors.

3. POTENTIAL ESTIMATE

Since new China was established，China has carried on seven forest reserves assessment. The seventh forest reserves assessment showed that nationwide wooded area covered 1.95 billion hectares in 2009，the percentage of forest cover was 20.36 percentage，and the forest stored up 137.27 billion cubic meters. At the same time, The Central

Party Committee and State Council published "Decision about Speeds up Forestry Development" in June, 2003, which estimated Chinese forest cover percentage would achieve 26 percentages in 2050. This article will estimate the existing trade potential of forest carbon sink and the future trade potential of forest carbon sink.

3.1 The Existing Potential Appraisal

According to result of seven national forest assessment, we can review the situation of existing forest resources in China, and then we will estimate the existing potential of forest carbon sink in China on this basis.

3.1.1 The historical alteration of Chinese forest resources

The data issued by seventh forest reserve assessment shows that potential of Chinese forest resources developing carbon sink enhances continually. It may include the following aspects:

The wooded area increase unceasingly:

Chinese forest resources area maintains the growing situation basically, especially since the third forest assessment, where the total area of forest resources grows unceasingly and the growth rate is also increasing. Compared with the sixth, the seventh nation forest assessment shows that net gains of the wooded area are 20.543 million hectares, and the percentage of the nation forest covers increases from 18.21 to 20.36, which roses 2.15 percentage. Wooded area's growth is the base of forest carbon sink growth and developing the forest carbon sink trade.

The quality of forest stores is growing unceasingly:

Stock volume per hectare increased by 2.61 cubic meters, and the average growth rate of forests accelerated. The forestry development has a full stamina. The planting area has the tendency to grow into a forest increases year by year. According to statistic, since 2001 the growth area of afforestation has achieved 800 million hectares every year, among which the proportion of young growth almost reaches to 70 percent. According to the related research, the ability of mature forest continues to absorb the carbon dioxide less than 5 percentages. However, the major part of Chinese forest belongs to the young growth, which lies in its exuberant vegetal period，and the forest's ability of absorbing carbon dioxide is in the high point. Thus，Chinese forest quality is improving progressively and the forest absorptive ability of carbon dioxide will enhance gradually too.

The quantity of forest stores is growing unceasingly:

The sixth national forest assessment shows that the quantity of forest stores up is 12.456 billion cubic meters. In the seventh national forest assessment, the quantity of forest stores up is 13.721 billion cubic meters, increased by 1.265 billion cubic meters and the yearly average net gains 22.3 million cubic meters compared to sixth time.

The carbon dioxide's absorbing capacity of forest has large potential:

Chinese forest acreage is only about 62 percent of world average level, probably situated world 130th. National forest's quantity of average stores up is only 84.73 cubic meters per hectare, which is 85 percent equal to world average level. The forest average diameter is only 14.8 centimeters, and the forest age group result is also incompatible. The above fact not only shows that the Chinese forest present existing question, but also indicates that forest resources' potential of absorbing carbon dioxide in China is huge.

The government attaché's importance to forest economy construction:

China has implemented the construction policy of "take the afforestation as the foundation", so the forestry construction work has made a certain progress. The seventh nation forest assessment indicates that the preservation area of China planted forest is 0.62 hectares, and the store is 19.61 billion cubic meters, in addition, the planted forest area continue to maintain the world top. Since 2002, the national afforestation and the re-afforestation area have developed at high speed, whose increment broke 100 million successively in six years. Recently, China has implemented six big projects, such as "to protect the wildwood" and so on, which support the growth of forest carbon sink. According to the stipulation in "the Kyoto Protocol", part of the developed countries (area) which had the reduced emissions target could counteract reduced emissions target partly by the carbon reserves formed by the project of the afforestation after the year of 1990. Chinese plantation area places first in the world, and, particularly after the year 1990, the afforestation area and re-afforest area maintains a quite high level. All these provide a very powerful condition for China to participate the international climate negotiations in the future.

3.1.2 Appraisal

Using the computational method of the forest carbon sink in this article, and combining with the seven national forest assessment results, we can appraise the reserves' change situation of Chinese forest carbon sink. The appraisal can be divided into the following two situations, and the results can be seen in table 1.

In the first situation: forest carbon sink only includes carbon sequestration of forest biomass:

Carbon reserves of forest biomass

= forest accumulation × expansion coefficient × volumetric coefficient × carbon rate

=V×1.9×0.5×0.5

In the second situation: forest carbon sink includes carbon sequestration of forest biomass, under-story vegetation carbon storage and carbon storage in forest.

Forest total carbon storage

= forest biomass sequestration + forest plant carbon sequestration + forest carbon sequestration

= $\sum$ （Sij×Cij） + α$\sum$ （Sij×Cij） + β$\sum$ （Sij×Cij）

= V×1.9×0.5×0.5+0.195 （V×1.9×0.5×0.5）

+1.244（V×1.9×0.5×0.5）

=2.4395（V×1.9×0.5×0.5）

Based on table 1, at present, Chinese carbon sinks potential is $6.52×10^9$ ton carbon, and, under the current international market, because the price of carbon maintained at 8-10 USD per ton, Chinese existing carbon sinks value is from $5.22×10^{10}$ to $6.52×10^{10}$. According to the exchange rate on June 30, 2010, which is one USD can be exchanged 6.7982 yuan RMB, Chinese existing value of the forest carbon sink is $3.55×10^{11}$-$4.43×10^{11}$ yuan RMB. If we consider the understory vegetation and forest carbon sequestration, then the total forest carbon sinks volume is$15.90×10^9$, and total forest carbon sinks value is $12.72×10^{10}$ to $15.90×10^{10}$.

Table1 Results of carbon storage of forest resources in China

forest number	checking pearied	forest coverage （%）	forest area （billion ha. ）	FC* （billion m^3）	FBCS* （ton）	FTCS** （ton）
1	1973-1976	12.70	1.22	86.56	$4.11×10^9$	$10.03×10^9$
2	1977-1981	12.00	1.15	90.28	$4.29×10^9$	$10.46×10^9$
3	1984-1988	12.98	1.25	91.41	$4.34×10^9$	$10.59×10^9$
4	1989-1993	13.92	1.34	101.37	$4.82×10^9$	$11.74×10^9$
5	1994-1998	16.85	1.59	112.67	$5.35×10^9$	$13.06×10^9$
6	1999-2003	18.21	1.75	124.56	$5.92×10^9$	$14.43×10^9$
7	2004-2009	20.36	1.95	137.21	$6.52×10^9$	$15.90×10^9$

Source: according to the data of China's national bureau of statistics (NBS) website
FC*:   Forest cumulating
FBCS**:   Forest biomass carbon storage
FTCS***: Forest total carbon storage

The research team lead by Professor Fang Jingyun in Beijing university studied the spatial and temporal changes of biological productivity of terrestrial vegetation and dynamic changes in carbon storage of Chinese forest vegetation over 50 years, using a series of field test data and the data of forest resource inventory last 50 years, using nearly 20 years of satellite remote sensing data and its suited climate, soil and vegetation information, and using the improved biomass conversion factor method. The results showed that carbon dioxide accumulation of Chinese forest increased from $4.38×10^9$ ton in the late 1970s to $4.75×10^9$ ton.

3.2 Evaluation of Future Potential

Evaluation of future potential of Chinese forest carbon sinks trade is mainly based on the article that

"Decision about Speeds up Forestry development", which was published by Party central committee and State Council, and through using forest accumulation expansion method assess the potential of China's forest carbon sinks trade.

3.2.1 Analysis of the trends in future forest resources of China

"The decision on accelerating the development of forestry" ,which was published by Party Central Committee and State Council on June, 2003, determined the main task of forestry future development in a long historical period: through managing the existing forest, expanding new afforestation, grasping changing cultivated land into forests, optimizing forest structure, increasing forest resources, enhancing the integral kinetic energy of forest ecosystems, increasing the effective supply of forest products, increasing the income of farmers and forestry workers. By 2010, the forest coverage rate will reach to 20 percent. Soil erosion of river basins and desertification of the main sandy areas have eased, the trend of deterioration of overall national ecological conditions have preliminary checked, and forestry industry structure will be more reasonable. By 2020, the forest coverage rate will reach to more than 23 percent, ecological problems of key areas have essential solved,

national ecological status have obviously improved, and the strength of forestry industry have significantly enhanced. By 2050, forest coverage rate will reach to and keep at more than 26 percent, Beautiful landscape and ecological condition into the virtuous cycle will come true. The contradiction between supply and demand of forest products will be relief, and we will build self-contained forest ecological system and relatively developed forestry industrial system.

3.2.1.1 Forest biomass carbon trade potential

In accordance with "On speeding up the development of forestry decision", the forest coverage rate will reach to 20 percent by 2010, 23 percent by 2020 and 26 percent by 2050. According to the calculation method of forest biomass carbon trade potential, we will calculate respectively in the following two cases of Chinese forest carbon trading results potential (see table 2).

The first kind of circumstance: accumulation of unit area remains present level as 84.73 cubic meters per hectares.

The second kind of circumstance: accumulation of unit area comes to international average as 100.00 cubic meters per hectares.

Table2 Results of China's future forest trees potential for carbon source*

forest coverage (%)	forest area (billion ha)	unit accum. (m^3/ ha)	Total accum. (billion m^3)	Total forest carbon sink	Based data (ton carbon)	carbon potential (ton carbon)
2010	1.92	84.73	162.68	7.71×10^9	6.52×10^9	1.19×10^9
20%		100.00	192	9.12×10^9	6.52×10^9	2.60×10^9
2020	2.21	84.73	187.25	8.89×10^9	6.52×10^9	2.47×10^9
23%		100.0	221	10.5×10^9	6.52×10^9	3.98×10^9
2050	2.5	84.73	211.83	10.06×10^9	6.52×10^9	3.54×10^9
26%		100.0	250.00	11.88×10^9	6.52×10^9	5.36×10^9

*According to the data of China's national bureau of statistics (NBS) website

According to the table 2, the forest coverage rate will reach to 20 percent per unit area by 2010 in China. If the accumulation volume keeps current levels, Chinese forest trees biomass carbon potential will be 1.19×10^9 tons carbon, which accounts for the existing carbon storage 18.25 percent. If accumulation volume reaches to international average 100 cubic meters per hectares in forest trees,

Chinese forest trees biomass carbon potential will be 2.60 x 10^9 tons carbon, which accounts for the existing carbon storage 39.88 percent.

The forest coverage rate will reach to 23 percent per unit area by 2020 in China. If the accumulation volume keeps current levels 84.73 cubic meters per hectares, China's forest trees biomass carbon potential will be 2.47×10^9 tons

carbon, accounted for the existing carbon storage 37.88 percent. If accumulation volume reaches to international average 100 cubic meters per hectares in forest trees, China's forest trees biomass carbon potential is 3.98×10^9 tons carbon, which accounts for the existing carbon storage 61.04 percent.

The forest coverage rate will reach to 26 percent per unit area by 2050 in China. If the accumulation volume keeps current levels 84.73 cubic meters per hectares, Chinese forest trees biomass carbon potential will be 3.54×10^9 tons carbon, which accounts for the existing carbon storage 54.29 percent. If accumulation volume reaches to international average 100 cubic meters

per hectares in forest trees, Chinese forest trees biomass carbon potential is 5.36×10^9 tons carbon, which accounts for the existing carbon storage 82.21 percent.

3.2.1.2 Forest all carbon trading potential

According to the calculation method of all carbon trade amount potential, we calculate forest carbon trading potential by 2010, 2020 and 2050 in China. We will calculate respectively in the following two cases of Chinese forest carbon trading results potential (see table 3).

Table3 Results of China's total future forest carbon sequestration potential*

forest coverage (%)	forest area (billion ha)	unit accum. (m^3/ ha)	Total accum. (billion m^3)	Total forest carbon sink	Based data (ton carbon)	carbon potential (ton carbon)
2010	1.92	84.73	162.68	18.84×10^9	15.90×10^9	2.94×10^9
20%		100	192	22.24×10^9	15.90×10^9	6.34×10^9
2020	2.21	84.73	187.25	21.69×10^9	15.90×10^9	5.79×10^9
23%		100.00	221	25.60×10^9	15.90×10^9	9.7×10^9
2050	2.50	84.73	211.83	24.54×10^9	15.90×10^9	8.64×10^9
26%		100.00	250.00	28.96×10^9	15.90×10^9	13.06×10^9

*According to the data of China's national bureau of statistics (NBS) website

One case of circumstance: accumulation of unit area remains present level as 84.73 cubic meters per hectares.

The other case of circumstance: accumulation of unit area comes to international average as 100.00 cubic meters per hectares.

According to the table 3, the forest coverage rate will reach to 20 percent per unit area by 2010 in China. If the accumulation volume keeps current levels 84.73 cubic meters per hectares, Chinese forest trees biomass carbon potential will be 2.94×10^9 tons carbon, which accounts for the existing carbon storage 18.49 percent. If accumulation volume reaches to international average 100 cubic meters per hectares in forest trees, Chinese forest trees biomass carbon potential is 6.34×10^9 tons carbon, which accounts for the existing carbon storage 39.87 percent.

The forest coverage rate will reach to 23 percent per unit area by 2020 in China. If the accumulation volume keeps current levels 84.73

cubic meters per hectares, China's forest trees biomass carbon potential will be 5.79×10^9 tons carbon, accounted for the existing carbon storage 36.42 percent. If accumulation volume reaches to international average 100 cubic meters per hectares in forest trees, China's forest trees biomass carbon potential is 9.7×10^9 tons carbon, which accounts for the existing carbon storage 61.01 percent.

The forest coverage rate will reach to 26 percent per unit area by 2050 in China. If the accumulation volume keeps current levels 84.73 cubic meters per hectares, Chinese forest trees biomass carbon potential will be 8.64×10^9 tons carbon, which accounts for the existing carbon storage 54.34 percent. If accumulation volume reaches to international average 100 cubic meters per hectares in forest trees, China's forest trees biomass carbon potential is 13.06×10^9 tons carbon, which accounts for the existing carbon storage 82.14 percent.

From the above analysis, we can see that

Chinese forest carbon potential is tremendous. On one hand, the development of Chinese forest carbon potential must rely on the increasing forest area. On the other hand, we should rely on improving forest management level and enhancing the accumulation of unit area. If only taking the extension to reproduction into account, Chinese forest carbon storage volume will increase by around 40 percent of the existing reserves by 2020, and net increment will reach to 5.79×10^9 tons carbon. Chinese forest carbon storage volume will increase by around 56 percent of the existing reserves by 2050, and all carbon trade volume will increase 8.64×10^9 tons carbon. So Chinese forest carbon trading has a huge potential market.

4. CONCLUSION

This article mainly use forest accumulation expansion method to do empirical analysis on China carrying out forest carbon trade potential, according to the data of previous national forest resources and "The decision on accelerating the development of forestry" published by Party Central Committee and State Council. The results show that China has huge potential for forest carbon sink trade, and the forest coverage rate will reach to 20 percent per unit area by 2010 in China. If the accumulation volume keeps current levels as 84.73 cubic meters per hectares, Chinese forest trees biomass carbon potential will be 2.94×10^9 tons carbon, which accounts for the existing carbon storage 18.49 percent. If accumulation volume reaches to international average as 100 cubic meters per hectares in forest trees, Chinese forest trees biomass carbon potential will be 6.34×10^9 tons carbon, which accounts for the existing carbon storage 39.87 percent.

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carbon, which accounts for the existing carbon storage 82.14 percent. These results show that China has huge potential of forest carbon sink. To express China forest carbon sink potential demands increasing in forest area, raising forest management level and enhancing accumulation volume per unit.

Correspondence to:

Haiyan Shen

Department of World Economics, Harbin Institute

of Technology，Harbin,150001,China

Ping Zhao

Department of International Economics and Trade,

Harbin Institute of Technology，Harbin,China

Address:

POB 232 ， 92 Xidazhi Street, Harbin, Heilongjiang 150001, China

Telephone: 01186-451-8641-3785

Cellular phone: 01186-139-3656-2750

Email: sdrzshy@126.com

zhf@hit.edu.cn

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