China-U.S. Potential Non-food Ethanol Exportation

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Abstract

To reduce national oil dependency, ethanol has been given a center stage of U.S. energy sources. The Renewable Fuel Standard (RFS) program was launched to increase the volume of renewable gasoline from 9 billion gallons in 2008 to 36 billion gallons by 2012, among which 15 billion are corn-based ethanol, while U.S. corn-based ethanol can hardly achieve this level. There is a trend that indicates U.S. importing ethanol from other countries, so a bilateral trade system has been established between U.S. and Brazil since 2003. The annual import is 211 million gallons in 2008 (USDC, 2009). Nevertheless, this amount is far away from the target, and the worldwide food shortage called us to divert our attention from fuel to food. China, as the third largest ethanol producer, has extreme ethanol growth potential with low production costs and large sources of cassava, which is a non-food feedstock for ethanol. This paper uses Data Envelopment Analysis (DEA) to measure and compare the efficiency of ethanol production in China and Brazil. To estimate the extent output can be proportionally expanded without altering the input quantities employed in each country. The output orientated method has been developed with annual ethanol production from the inputs--land for ethanol crops, agricultural labor force and capacity of ethanol production. The DEA results show that China has been more efficient in ethanol production than Brazil since the year 2007. This means China has comparative advantage over Brazil in producing ethanol, hence U.S. can import from China instead of Brazil in the future.

Keywords: Ethanol, Efficiency, Non-food, Productivity, Feedstocks

Background

The U.S. consumes over 140 billion gallons of gasoline a year, and imports 424 million gallons of Crude Oil per day (EIA, 2006). Aims to reduce oil dependency, President Bush's 2007 State of the Union Address gave ethanol a center stage. Bush set a goal to produce 35 billion gallons of alternative fuels by the year 2017 as part of a plan to reduce U.S. gasoline consumption by 20 percent in the next 10 years (EFC-UNF, 2007). Meanwhile, since traditional gasoline contributes to the release of green house gases into the atmosphere and global warming, the U.S. Environmental Protection Agency (EPA), under the Energy Independence and Security Act of 2007 (EISA, 2007), is responsible for revising and implementing regulations to ensure that gasoline sold in the U.S. contains a minimum volume of renewable fuel. The Renewable Fuel Standard (RFS) program will increase the volume of renewable gasoline from 9 billion gallons in 2008 to 36 billion gallons by 2012, among which 15 billion gallons are corn-based ethanol. Nevertheless, U.S. corn-based ethanol production can hardly achieve this level.

Last decade, the abundance and affordability of feed stocks and the supportive political framework have pushed ethanol fuel into the widespread fuel energy sources worldwide. At the year of 2006, U.S. exceeded Brazil to be the largest producer of fuel ethanol (RFS, 2007), nonetheless, we consume more than we produce. Most of U.S. factories use corn to produce ethanol, which accounts for about 14% of corn use and about 3.5% of overall gasoline usage in the 2005/2006 harvest year (OCE–USDA, 2007).

Corn-based ethanol production has been very profitable over the past few years, Federal and state subsidies for corn ethanol production are more than $7 per bushel (Domestic Fuel, 2006). Some industries are making huge profits from ethanol production through these subsidies. At the dawn of ethanol age, Policy makers believe that ethanol production provides large benefits for farmers, but the near doubling of corn prices in late 2006 and early 2007 has significantly reduced ethanol plant profitability (Outlaw, et. al., 2007). Although people believe ethanol has a positive net energy balance and has a less harm impact on the environment than other petroleum derived product, scientists argue that corn ethanol production actually increases environmental degradation instead of protecting the environment, not by ethanol itself, but because corn production causes soil erosion which seriously pollutes the watersheds (Cassman, 2006). Moreover, diverse cereal grains make up 80 per cent of the human food supply all over the world, the worldwide food shortages call attention to the importance of ensuring U.S. exports of corn as food crop for human nutrition (Pimentel and Patzek, 2007).

Beside the United States, Brazil has the expertise and capacity to produce ethanol. As the world's largest sugar producer, Brazil divides sugarcane equally into sugar production and ethanol production. Since the U.S. is working hard in getting rid of oil dependency, while Brazil has the largest surplus of the perfect substitution of traditional gasoline—fuel ethanol, a bilateral trade system has been established since 2003. The amount of annual imports increases from 94 million gallons (2003) to 211 million gallons (2008) (USDC, 2009). Nevertheless, the worldwide food shortages brought attention to the importance of ensuring U.S. and Brazilian exports of food crops for human nutrition. However, corn and sugar based ethanol production boom diverts valuable cropland from the production of food crops to nourish people. During this situation, a balance between using crops as food and for fuel has been a concern (EHP, 2008).

As the environment, economy and food issues have been discussed extensively; a technology of using non-food feedstock has been evoked. Consequently, research on non-food biofuel became popular worldwide. Non-food ethanol can be made from a variety of sources that might otherwise be considered waste – uneatable cassava, cellulosic, sewage sludge, switch grass, plant stalks and trees – virtually anything that contains carbon (BIO 2006). After the proposal of non-food ethanol manufacturing, many firms are supporting and investing in it. Dupont Genencor invests $140M in Cellulosic Ethanol Joint Venture (Environmental Leader). General Motors (GM) is investing in a fledgling company that claims its secret process could be able to make ethanol from waste in large quantity as soon as 2010 for $1 a gallon or less, half the cost of making gasoline (USA TODAY). Range Fuels announced that it raised more than $100 million to help finish construction of its Soperton, Ga., cellulosic ethanol plant (BIO). BlueFire Ethanol becomes a leader in

Cellulosic Ethanol Technology announced that it will break ground soon on its first commercial cellulosic-ethanol plant (bluefire ethanol).

In the era of nonfood fuel ethanol, there is a potential for China to export ethanol from cassava at a cost more competitive than what Brazil is currently offering. Cassava is widespread feedstock for fuel ethanol in Asia. It was approved to be adapted well to a wide range of growing conditions and require minimal inputs. China currently cultivates around 500,000 hectares of cassava, most of them a re inedible bitter type, of which 200,000 are destined for ethanol production. Moreover, unlike sugar-based distilleries that are seasonally operated, cassava-based ethanol plants can run year round (EST, 2005).

Land has been used intensively in China. The third largest country on the earth, contains 1.3 billion residents while 0.84 billion of them are agricultural workers (FAO). Since agriculture is the soul of China, when the idea of cassava ethanol was proposed, government and enterprises started to focus on it immediately (Li and Chan, 2009). As feedstock for fuel ethanol, cassava has two main advantages over other feedstocks such as corn and sugarcane. First, cassava can be cultivated on marginal lands where edible crops such as corn, wheat, rice and sugarcane cannot be grown well (Zhang, Han, Pu, Wang, 2003). Second, cassava is not a staple food for the Chinese people.

The Chinese government, since 2005 has been promoting the use of non-food grain feedstocks that could sustainably grow on marginal and abandoned lands to feed the biorefinery industries for ethanol production (Dai, Hu and Pu, 2005). In four years, China has become the world's third largest producer of fuel ethanol and a focus of considerable attention of many countries given the potential size of its market. In 2008, Brazilian Agricultural Research Enterprise (EMBRAPA) and Chinese Academy Tropical of Agricultural Science (CATAS) launched a cooperation program to conduct research in recently discovered type of cassava for bio-ethanol. Studies show that non-grain crops in China could eventually produce as much as 300 million tones of ethanol a year (NDRC, 2007). Currently, China exports some few million gallons of ethanol to the U.S. But this amount could rise sharply if the productivity of ethanol rises in the country. If U.S. can find a way to harness the bilateral trade of ethanol with China, the third largest ethanol producer may help us with getting rid of oil dependency, food shortage by its potential non-food feedstock developing.

Potential for China Exporting Ethanol to U.S.

Over the last six years, since China began to produce fuel ethanol, the average price of Chinese ethanol is only $1.65 per gallon (Xinhua, 2008), while that of U.S. main importing country Brazil is $2.19/gallon (Sao, Paulo), which is 32.7 percent higher than Chinese price. However, the total import from China is only 89.24 million gallons, which is only 4 percent of Brazilian importing (ITC, 2009). With the use of lead free gasoline in China from July 2000, the local government of Guangxi is launching an ambitious program of production of fuel ethanol from cassava (Dai, Hu, Pu, Li, and Wang, 2006).

This paper examines the potential of China being the major source of U.S. ethanol imports in future instead of Brazil by measuring and comparing the efficiency of Chinese and Brazilian ethanol production. We hypothesize that the Chinese cassava ethanol is more efficient, because of the multiple feedstocks and abundant agricultural land. Their production will increase rapidly to pass Brazil. This gain in production efficiency will lead to lower prices and, U.S. would as a matter of economic reasons consider China as the future trade country.

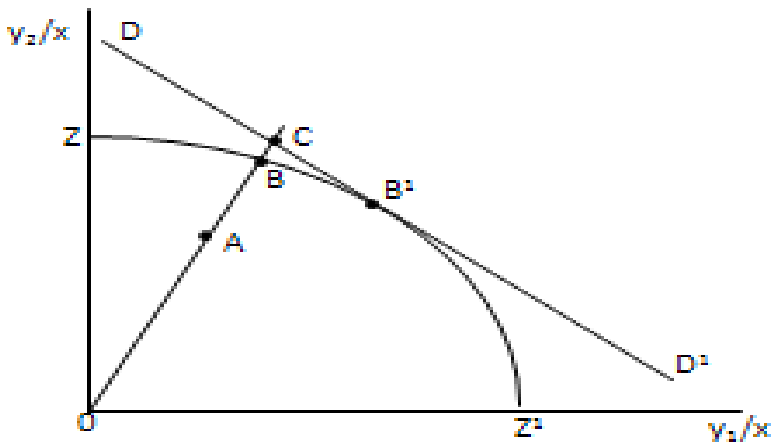
Methodology and Data

Aggregate data on total seasonal ethanol production and inputs for production (land, labor, bio-refinery capacity, cassava as a feedstock in China, and sugar cane for Brazil) has been collected from 2003 to 2008. This study focuses on the ethanol productivity efficiency of the two countries using Data Envelopment Analysis (DEA). DEA is a mathematical programming approach to frontier estimation (Coelli, 1996). In this paper, output- orientated is used instead of input-orientated method, to estimate the expansible output quantities without altering the input levels employed.

Measurement of Efficiencies

The efficiency measured consists of two components, technical efficiency (TE_0) and allocative efficiency (AE_0), theses two measures are combined to provide a measure of total economics efficiency (EE_0). Figure 1 below describes the measurement of efficiencies.

Figure 1. Efficiency Measure from an Output Orientation



Considering a unit production possibility curve ZZ^1 for two outputs y_1 and y_2, the point A represents an inefficient firm since it lies below the curve ZZ^1. DD^1 is the isorevenue line. The distance AB therefore represents technical efficiency which is also the amount by which output can be increased without employing additional input.

Technical efficiency (TE_0) reflects the ability of a country to obtain maximal output from a given level of input, measured as $TE_0 = 0A/0B$

Allocative efficiency (AE_0) reflects the ability of a country to use the input in optimal proportions, measured as $AE_0 = 0B/0C$

Overall Economic Efficiency (EE_0) shows the product of TE_0 and AE_0

$EE_0 = (0A/0C) = (0A/0B)*(0B/0C) = TE_0*AE_0$

Data on ethanol production has been collected from the Renewable Fuels Association (RFA) at http://www.ethanolrfa.org/industry/statistics/, agricultural land and labor information has been collected from the Food and Agriculture Organization of the United Nations (FAO) at http://www.fao.org/corp/statistics/zh/, data on capacity of ethanol production in Brazil is from the Association of Equipment Manufacturers (AEM) at http://www.aem.org/Stats/, data on the capacity of ethanol production in China is from the Chinese Cassava Ethanol Union at http://www.cncassava.com/, and a research on area use for ethanol crop/total arable land has been studied from the Bioenergy Site at http://www.thebioenergysite.com/news/category/4/ethanol.

The descriptive statistics of the variables are presented in table 1. The average crop input is 5,118.8 and 380.4 million dollars, the average arable land is 59,460 and 137,735.8 thousand hectares, the average agricultural population is 25,529 and 837,905.2 thousand, the average ethanol productivity is 4,350,000 and 16,380 thousand gallons, for Brazil and China respectively.

Results and Discussion

Table 2 reports the results of the DEA analysis. Although China has lower technical efficiency at the beginning in the year of 2005, it increased tremendously. The overall estimation reveals both Brazil and China are efficient in ethanol production, but China has comparative advantage in technical efficiency (TE) in recent two years, implies U.S. can import from China in the future.

The allocative efficiency (AE) of Brazil and China is 1.000, means both of the two countries use the input in optimal proportions. Nevertheless, China has higher technical efficiency than Brazil in the last two years. Technical efficiency of Brazil in the year 2007 and 2008 is 0.896 and 0.950 respectively, while that of China is 0.908 and 0.965 respectively. That indicates China obtains more output than Brazil from a given level of input. The reason why China exceeds Brazil in technical efficiency is that cassava adapts well to a wide range of growing conditions and requires minimal inputs (Nguyen, 2007). Moreover, unlike sugar-based distilleries that are seasonally operated, cassava-based ethanol plants can run year round (EST).

Conclusion

In recent years, the cassava-based ethanol industry in China has grown rapidly, stimulated by renewable energy concerns, new fuel standards and government incentives. Using cassava for ethanol production would not raise major ethical and moral issues as corn ethanol (Pimentel, 2003). Instead of producing more ethanol by corn domestically, U.S. should consider to import non-food ethanol from the world.

Ethanol industry operating costs are much lower in China than Brazil because of the cheaper labor force and intensive using of land. Moreover, the results reveal that technical efficiency increased tremendously in the last decade, which implies China obtains more ethanol than Brazil from a given level of input recently. U.S. should therefore plan taking China as an ethanol importing partner in the future.

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Table 1. Descriptive Statistics of Variables

Variable	Units	Mean	Standard Error	Minimum	Maximum
Brazilian Crop Input	Million USD	5,118.8	510.829	4,073	6,673
Chinese Crop Input	Million USD	380.4	43.109	264	502
Brazilian Arable Land	Thousand Hectare	59,460	50.99	59,300	59,600
Chinese Arable Land	Thousand Hectare	137,735.8	1,870.659	131,646	142,131
Brazilian Ag. Population	Thousand	25,529	258.447	25,019	26,400
Chinese Ag. Population	Thousand	837,905.2	3,101.739	830,217	845,134
Brazilian Ethanol Productivity	Thousand Gallon	4,350,000	276,061.587	3,730,000	5,380,000
Chinese Ethanol Productivity	Thousand Gallon	16,380	976.933	13,400	19,300

Table 2. Results from the Data Envelopment Analysis (DEA)

Country	Year	Efficiency Change	Technical Change	Pure Efficiency Change	Scale Efficiency Change	Total Factor Productivity Change
Brazil	2004	1	0.992	1	1	0.992
China	2004	1	0.892	1	1	0.892
Brazil	2005	1	0.996	1	1	0.996
China	2005	1	0.909	1	1	0.909
Brazil	2006	1	0.963	1	1	0.963
China	2006	1	0.926	1	1	0.926
Brazil	2007	1	0.896	1	1	0.896
China	2007	1	0.908	1	1	0.908
Brazil	2008	1	0.950	1	1	0.950
China	2008	1	0.965	1	1	0.965