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論文題目　Fuel-ethanol Development in China: Production Potential and Possible Impacts on Agriculture
(中国における燃料用エターノールの展望：潜在的生産力と農業生産へ及ぼす影響)

The rapid increase of China economy has raised growing concerns on the nation's energy security. With the rapid increase of domestic energy production, demand has grown even faster. China has shifted from a net energy exporter to a net importer since the late 2000s. In recent years, China is becoming one of the largest energy importers in the world. The major rise in energy import has come from the increase in oil demand for transportation. In terms of large increases in energy consumption in the near future, however, the Chinese government established a national strategy for oil security and commenced two programs of "Denatured Fuel Ethanol" and "Ethanol Gasoline for Motor Vehicles" in 2001. The main objective of the plans was to experiment with fuel-ethanol production, marketing and support measures. Meanwhile, the programs set a target of annual fuel-ethanol production at 10 million tons in 2020. The sudden increase in demand for fuel-ethanol has opened up a new opportunity for feedstocks for ethanol production. However, a question arising is whether the energy crop production in China has potentials to meet the increase in the demand for ethanol production, in addition to the conventional demand. Moreover, according to the cost comparison of ethanol production by countries, China's current ethanol production costs are not as competitive globally.

The main feedstock for fuel-ethanol production in China used to be maize and wheat. However, since 2005, the "old" maize and wheat have been used up with increasing concern on the trade-off between food (grain) security and energy use, China government started to regulate grain-based ethanol production. The government

states that it will strongly pursue the development of non-food crop based fuel-ethanol production; the feedstocks will eventually shift from maize and wheat to non-food crops that do not compete with arable land. Thus, sugarcane and cassava are considered as the prioritized and potential crops for fuel-ethanol production in China.

A prerequisite for the large-scale production of dedicate bioenergy crops and trade of modern bioenergy is not only with respect to increase agricultural productivity, but also with respect to use a sustainable production way. In order to examine whether the sugarcane and cassava production in China has potentials to meet the increase in the demand for ethanol production, firstly this study examines the structure of sugarcane production and cassava production in China, using the data obtained from farmers in major producing regions in China by adopting the stochastic frontier analysis. Secondly, the sustainability of each crop production is evaluated. A set of criteria is defined including 3 concerns from environmental area and 2 concerns from socio-economic area.

According to the stochastic frontier analysis, the mean technical efficiency (TE) of sugarcane production is 94%, and the mean cost inefficient is 1.05%, indicating that, there is a small scope to increase sugarcane production by enhancing farmers' technical efficiency under the present technology. As for the cassava production, the cost inefficiency index is estimated to be 1.04%, under the present available technology, cassava production could be increased by 4%. Furthermore, from the aspect of sustainable production, the ethanol production from sugarcane has larger impacts on the environment compared to the cassava-base. Competition with food production and water requirement are potential bottlenecks for a sustainable sugarcane-based ethanol production. Cassava-based ethanol production requires lower agro-fertilizer use and higher rates in ethanol conversion.

Fuel-ethanol production has become a high priority issue in China in recent years. Due to the government policy support, the crop has been apt to preempt use for ethanol production. However, another issue arose, how does China's fuel-ethanol expansion affect its agricultural, including prices, production and national food security? From 2006 to mid 2008 almost every country and certain regions in the world were significantly affected by sharp increases in prices for food commodities and products. In order to analyze the factors contributing to the rise in food commodities prices, we used a global, general equilibrium model. The GTAP model and GTAP version 7 data base were used. Many factors are contributing to higher grains price; the simulation results show that higher oil price, production of fuel-ethanol and government policy intervention are the keys factors to cause the world grains price volatility. As for the Chinese national market, the increases and the fluctuations of the main agriculture goods prices in international markets from 2006 to 2008 were not reflected immediately in the Chinese market for these goods. By releasing national grain stocks and taking export restrictions the Chinese government effectively kept China's grain markets isolated from the rapid grain prices increase in the world markets, at least in the short run. Except sharp increase in soybean price, the others grain prices were drastically lower than the international prices. Without the government control, the combined impact of higher oil price and fuel-ethanol

production would increase grain prices more than 60%. However, these policy interventions have some harmful effects on farmers. Price control and export tariffs make production less profitable, which discourage supply and can make shortages worse. If the subsidy to agricultural production be reduced or abolished, the farmers cannot stay in business. In China most all of the poor are farmers. As the food price increase, the consumers and the framers have conflicting interests, the government always chooses to protect the former.

As for the likely impact of fuel-ethanol expansion in a long run, the study also formulated a scenario of long-term fuel-ethanol production: the implementation of fuel-ethanol target in 2020 is applied as an example of mandatory fuel-ethanol production in China. To analyze the consequences of the fuel-ethanol production in the agricultural market for agri-food products, the study runs two scenarios; the reference scenario which does not include any fuel-ethanol production obligation and the fuel-ethanol directive scenario including fuel-ethanol target in China in 2020. The simulation results show that that enhanced production for fuel-ethanol under the fuel-ethanol target has a strong impact on Chinese agriculture. The target has two effects, a direct effect with increase in energy crops production directly used in the ethanol sector and a indirect effect where the use of fuel-ethanol crops is redirected from feed and food use to fuel use. Fuel-ethanol development in China will have significant impacts on the prices of the feedstock. The projected increase in the prices of the feedstock will trigger significant increases in the production of these commodities. The harvested area of cereal grains is projected to increase by 25%, while the production increase by 32% as a result of increasing intensification of ethanol production. The sugarcane production will decline by 1% mainly due to the export decline by 32.5%, however, the domestic demand for sugarcane will increase by 30.8%. In addition, the simulation results show that China will become a net importer for agricultural commodities. The imports of cereal grains, sugarcane and rice are expected to increase by 38%, 48 % and 72%, respectively. And exports are expected to fall by about 33% for cereal grains, 73% for sugarcane and 129% for rice. Domestically produced fuel-ethanol feedstock will only partially meet demand and China will incur a higher agricultural trade deficit. The total welfare loss is huge.

The increased demand for food and the increasing interests in fuel-ethanol have created a new challenge for government at all levels. Fuel-ethanol expansion is not only an energy issue, but also must by approached form energy, agriculture and conservation perspectives. The results from this study have important implications for future fuel-ethanol expansion in China.

In order to take advantage of international competiveness of ethanol production and increase China’s grain self-sufficiency rate, Chinese government should strengthen the reconstruction of low-yielding fields. There is a small scope for sugarcane and cassava to increase production by reducing the technology gap between the existing potential and farmers’ technology. If the efforts to enhance farmers’ technical efficiency are coupled with ensure safeguards on land rights, not only crop production increases but also rural poverty is mitigated. However, if both sugarcane and cassava production were to be increased substantially, the most credible way is to develop new

technology that enhances crop yield per unit of land area particularly by improving the labor productivity. The field surveys suggest that if new technology were to be developed, serious attention should be paid to design the new technology environment friendly, since farmers' practices in crop production are not generally sustainable in China. Compare the technical efficiency and sustainable production between the usages of sugarcane and cassava as fuel-ethanol feedstock; we suggest that cassava which requires low agro-fertilizer use should be recommended as a prior energy crop in China with higher rates in ethanol conversion and dry matter.

In additional, Chinese policy interventions of releasing grain stocks and restriction exports may have kept the grain prices in national market lower than the world market over the past years; however, in the long run it will become almost impossible to keep the relative lower prices. The national grain stocks will run out, and if demand for grain grows faster than supply China may have its own food crisis in the future. Thus, the government needs to prepare to accept the food price rise. Some of the actions the government should be taken. Firstly, the government needs to make more effort on increasing agricultural production. High price can increase production incentives. Especially when more public investments to improve productivity and perfect infrastructure put into the agricultural sector, high food price can be as an opportunity to spur rural economy and increase farmers' income. Secondly, it is necessary to enhance the social security system in the rural and urban areas to provide support for the poor. The last but not the least, China's fuel-ethanol policies should be reconsidered. Less direct subsidies and more indirect subsidies are needed. When it is an infant industry, the heavily governmental subsidies to producing farmers and capped price for downstream consumers might be necessary. However, in the long run, to operate an efficient industry the direct subsidies need to be gradually reduced. The government should support indirect subsidies to the industry through funding research on innovative technology. Elimination of subsidy would save tax-players money and stabilize grain prices when the oil price is already high. In additional, the alternative policy should be countercyclical to the oil price, which decreases upward price pressure on grain prices when oil price is high but would not reduce price pressure when grain supplies are low. The government should permit more market competition and allow the market to function more efficiently and less market regulations are expected in China's agricultural markets.