Trade and Economic Implications of Low Level Presence and Asynchronous Authorizations of Agricultural Biotechnology Varieties:

A Case Study in China

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1. Introduction

Biotech crops, also known as genetically modified (GM) crops, have been considered as one of most promising but also highly regulated crops. After the first approval for commercialization of biotech crops in US in 1996, there are more than 120 biotech events and 24 biotech crops have passed the strictly regulatory hurdle in both developed and developing countries by 2010 (James, 2011). In 2010, there are 29 countries planted biotech crops with a total area of 148 million hectares.

China is one of major countries that have strong biotech program. China's modern biotech program has grown into the largest initiative in the developing world. The national leaders and leading scientists in China believe that GM technology is one of the major tools that will help boost agricultural productivity and improve the national food security. Public investment in biotech crops and livestock has doubled every 3-4 years in the past decade (Huang et al., 2005). In 2008, China initiated a new GM program with a total budget of U.S. $ 3.8 billion in 2009-2020, focusing on GM rice, wheat, maize, cotton, soybean, pig, cattle and sheep.

China has also commercialized several biotech crops since 1997. China had approved the commercialization of biotech GM cotton, petunia, tomato, sweet pepper, poplar trees and papaya before 2006. Bt cotton is the most successful story of China's biotech program. Its area reached 3.7 million hectares in 2009 (about 70% of total cotton cultivation in China). Bt cotton, compared with non-Bt cotton, has raised cotton yields and allowed farmers to significantly reduce their pesticide use (Huang et al., 2002a and 2003).

In 2009, the Ministry of Agriculture issued production safety certificates to Bt rice and phytase maize in 2009 and there, there are also several other biotech crops in the pipeline. Approval of biosafety for biotech rice and maize is a milestone of China's biotech development. It has moved China's biotech crops from fiber to major feed and food crops, which is expected to have significant implications for biotech development in the rest of world and trade flows between China and its major trader partners. As Bt rice and phytase maize still need to go through regional varietal demonstration and registration in the coming years, it is expected that they will be cultivated for large scale production within 3-4 years. Biotech maize, wheat, and soybean are also in pre-production stage, the last stage of biosafety regulation before they will be issued biosafety certificates for production.

China has also developed a comprehensive biosafety regulation and monitoring system for both domestic GM crop commercialization and GM crop import. With 15 years of biotech crop commercialization experience, China already has a well-established domestic case-by-case regulatory system to commercialize its biotech crops (Huang et al., 2008). However, it is interesting to note that while China has commercialized several GM crops and there are also a significant number of GM crop events in the R&D and regulatory pipeline, China has not started to seek for approval of its GM crop events in any foreign country. Exporters of Chinese commodities, particularly rice and processed rice food exporters, have started to concern that China's current policy of seeking only domestic approval of GM crops could lead to low level presence (LLP) of GM events making their way into Chinese exports of commodity shipments and processed foods. On import, China has set up its case-by-case regulatory system to import its GM food and feed. The nation has experienced with importing GM soybeans and soybean oil for more than 10 years and GM maize in recent years. China is the largest biotech soybean importer. Recently, China has shifted from maize exporter to importer.

According to China's agricultural import biosafety regulation, any request for import approval in China for commodities with GM event can be started only after the event had been approved in the exporting countries. The asynchronicity of approvals in China and exporting countries together with China's policy on a zero tolerance level for unapproved GM products have raised many concerns by the exporters in US and other countries as well as biotech companies in the rest of world.

The purpose of this paper is to examine the implications of LLP of agricultural biotech varieties on international trade and food prices in China and its major trade partners. To achieve this goal, we select rice, soybean and maize as major biotech crops for case studies. Rice is an exportable commodity in China. China has been one of major rice exporters with average annual export of about 1.5 million tons in the past 2 decades (NSBC, 2010). Although its export declined in recent years, China export of processed rice foods has been rising (Wang 2009). Import of biotech soybean has significantly increased and reached 54 million metric tons in 2010 (NSBC, 2011). Imports of maize and dried distillers grains (DDG, by-products of ethanol production from maize) recorded 2 million tons and 3 million tons, respectively in 2010 (FeedTrade, 2011). Although import of maize has occurred only in recent years, it is expected that imports of maize will continue to rise in the future (Huang et al., 2010).

This paper is organized as the follows. Section 2 discusses China's authorization procedure for agricultural biotech product, particular for biotech crop import, and examines China's GM products in the pipeline that may inquire authorizations to seek for biotech products in other countries. Section 3 presents China's trade of rice, maize and soybean and assesses the likelihood of low level presence of biotech crops in both China's import and export. Section 4 presents methodology and scenarios and section 5 shows the results on the impacts of LLP on trade, production and prices of major agricultural commodities. The last section concludes this study.

2. China's national biosafety regulations and approval process for GM events

2.1 An overview of China's biosafety regulation

In response to the emerging agricultural biotechnology, China has established and improved its legal and regulation system for agricultural biosafety since early 1990s. The first biosafety regulation, "the Measures for Safety Administration of Genetic Engineering," was issued by the Ministry of Science and Technology (MOST) in 1993. This regulation consisted of general principles, safety categories, risk evaluation, application and approval, safety control measures, and legal responsibilities. Following MOST's guidelines, the Ministry of Agriculture (MOA) issued the

Implementation Measures for Safety Control of Agricultural Organism Biological Engineering in 1996. It covered the plant, animal and microorganism. The Implementation Measures provided detail regulation procedures that need to meet the necessary biosafety requirements in each stage of GM organism (GMO) development. Safety regulation has followed a case-by-case procedure. However, labeling was not part of this regulation, nor was any restriction imposed on imports or exports of GMO products. The regulation also did not regulate processed food products that use GMOs as inputs. Under this regulation the Biosafety Committee was established in 1997 to provide MOA with expert advice on biosafety assessments.

With continued development of agricultural biotechnology, rising GMO imports and consumers' concerns, China has periodically amended its biosafety regulations since 2001. In May 2001 the State Council decreed a new regulation to replace the previous one issued by MOA in 1996. This amended regulation at national level, "Regulation on the Safety Administration of Agricultural Transgenic Organisms," includes trade regulation and labeling of GM farm products, which has been in effective after May 23, 2001. Based on this new regulation, the Ministry of Agriculture issues three implementation regulations on biosafety management, trade, and labeling of GM products that were put in effective after March 20, 2002.

The 2002 amended regulations that expanded to trade and labeling of GM products were responded to the rising imports of GM products, particular GM soybean and edible oils, and present of GM foods in the market. One of key policy that may have important implications to GM industry and trade is a "zero tolerance level for unapproved GM products" in both labeling and import. The list of agricultural GMOs applied labeling includes 17 products from 5 crops. They are soybean seeds, soybeans, soy flour, soy oil, soy meal; corn seeds, corn, corn oil, corn flour; rape seeds for planting, rape seed, rape seed oil, rape seed meal; cotton seeds for planting; tomato seeds, fresh tomatoes, and tomato sauce. Detail regulations and procedure for approval of importing GMO products has also been developed and implemented since 2002 (see more discussion in the later part of this section.)

MOA is primary institution in charge of the implementation of agricultural biosafety regulations. The governing body under MOA is the Leading Group on Agricultural

GMO Biosafety Management, which directs the routine works and daily managements of Agricultural GMO Biosafety Management Office (BMO). The biosafety assessments are conducted by the National Agricultural GMO Biosafety Committee (BC). Currently, they meet three times each year to evaluate all biosafety assessment applications related to experimental research, field trials (small scale trial), environmental release (medium scale field trial), pre-production trial (large scale field trial), commercialization of agricultural GMOs, and events for import of GM products. They provide approval or disapproval recommendations based on the results of their biosafety assessments. Based on BC's technical assessments and other consideration (e.g., social, economic and political factors), BMO prepares the recommendations to the MOA's Leading Group for the making decisions.

Followed the biosafety regulations, MOA had approved a number of biotech events for commercial production or field trails. By 2010, MOA had issued biosafety certificates for production to 8 plants (Table 1). Meantime, MOA has also issued biosafety certificates for field trial or pre-production trail to wheat, soybean, rapeseeds and other crops (Table 1).

It is interesting to note that despite the rising biotech events approved by MOA, China has not make efforts to seek for approval of GM crops in other countries. This may be due to the fact that, among approved events (Table 1), Bt cotton is only crop that has been widely adopted by farmers. For other biotech crops, China has not seek for approval in foreign countries may also be explained by the goal of China's biotech program that is aimed to improve domestic agricultural productivity and national food security. China is not expected to be a major exporter of food and feed in the future (Huang et al., 2010).

However, exporters of Chinese commodities, particularly rice and processed rice food, have started to concern that China's policy of seeking only domestic approval of GM crops could lead to low level presence (LLP) of GM events in China's export. It was reported that the rice products exported from China to EU contained the illegal GM event (Terra Daily, 2006). The European Commission enacted an emergency regulation on Chinese food imports in 2008. Food products imported from China has to be tested for GM free since April 2008 (TIME, 2008).

2.2 Biosafety regulation process for import of GM products

Any application for field trials, commercialization and import of GMOs, developed either by domestic institutions/companies or foreign institutions/companies, within the territory of China must follow the process specified in the Biosafety Regulation.

On China's import of GMOs (Figure 1), the following steps have to be completed by company or GM technology inventor for any GM event.

1）Submit application dossier to BMO for import permit of seed that contents the event. In addition of the required application documents, foreign institutions or companies must submit the related certificate of biosafety approvals from the original country.

2）Evaluate application. MOA's BMO evaluates the completeness of application materials.

3）Obtain seed import permit from MOA. After the application, MOA's BMO organizes biosafety evaluation and make recommendation on whether or not to allow importing GM seed for food and feed safety and environmental safety trails. The evaluation is conducted by BC, which was held twice a year in the past and is held three times in early, middle and late of each year in recent years.

4）Apply for seed import license. With MOA's seed import permit, apply for seed import license from seed management authorities in local province(s) and MOA's seed division, and meet plant quarantine requirements from quarantine inspection and monitoring authorities. This process normally takes 4-6 months.

5）Conduct biosafety trails. This is undertaken by the MOA's authorized agricultural biotech inspection institutions. A typical food and feed safety trail is to feed rat 90 days. The environmental trail is conducted at field during the crop growing season. For maize, environmental trial takes about 110 days. Total cost is 310,000 yuan (about USD 48 thousand in 2010). Based on the results of biosafety trails, an authorized institution prepares a comprehensive biosafety trail report and submits it to MOA.

6）Evaluate biosafety trail report. The report is evaluated by MOA’s BC. As mentioned early, BC members meet three times each year in recent years so that there are three chances for any biodafety trail report submission each year. If a report passes BC’s evaluation, BC recommends MOA’s BMO to issue GMO import permit for processing, food and feed uses. Otherwise, additional data or information may be requested by BC, which can lead to delay in completing application process.

7）Obtain permit for GM event import. A final decision to approve GM product import is made by the ministry of MOA.

A successful application to complete the above processes lasts for about 2 years. However, a delay in any of above seven steps could lead to additional few months or even one year to obtain GM import permit.

If a GM event is approved after undergoing regulatory review in China, the MOA then places the event on a list of products approved for import. For all approved GMOs, exporters (typically foreign trade firms that are selling food commodities into China) have to apply to the MOA for an export permit. At the same time importers (typically domestic firms inside China) must apply for import permits. In principle, exporter from foreign countries should follow the following steps to export GM products to China, which normally take about a couple of months:

1）Submit application to MOA’s BMO for import permit of GMOs that contained the event.

2）Evaluate import application by MOA. After the application, MOA’s BMO organizes biosafety evaluation and make recommendation on whether or not to allow importing the GMOs for processing of food or feed uses.

3）Obtain import license. After BC recommends MOA's BMO to issue import permit for processing (food and feed) uses, a final decision to approve GMO import is made by the ministry of MOA.

Compared with obtaining GM event permit application, process for trade permit is relatively simple. Requests for export or import permits have typically taken no more than 30 days to issue (Huang et al., 2008). Since ordering, executing and fulfilling the importation of a large soybean or maize shipment from another country into China is a time consuming process (typically 3 to 6 months), as long as the applications for import and export permits are started early in the process, they do not restrict trade or add any holdup costs to the importation process beyond the actual fees paid. In each port there are local authorities that are responsible for ensuring compliance of the shipment with the approval certificates, mostly through laboratory testing.

When the tests prove the importer is in compliance, the shipment is released for unloading as long as the fees for the tests have been paid. According to China's regulations, for the first 10,000 tons, 20 samples are randomly chosen. After the first 10,000 tons, an additional sample is randomly chosen for each 1,000 tons. Therefore, for a 60,000 ton vessel that is fully loaded, a total of 70 samples need to be tested. The tests are done in a local laboratory that is under contract to the port biosafety authority. The tests performed are essentially equivalent to a test needed to identify whether or not the shipment contains GM events and what types of GM events are present. Details of testing procedure are discussed in Huang et al. (2008).

Based on China's biosafety regulations, MOA has approved three major GM events of soybean (Table 2). Although there are much more events approved for soybean in major soybean producing countries, because GM soybean exported to China from USA, Brazil and Argentina all belong to the three approved events,[1] there is no trade rejection happened in last ten years. However, the difference in approved events between China and its main exporters still presents a likely risk for traders to export soybean to China.

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[1] Roundup Ready™ (OECD Identifier: MON-Ø4Ø32-6), Genuity Roundup Ready 2 Yield™ (OECD Identifier: MON-89788-1), and LibertyLink™ (OECD Identifier: ACS-GMØØ5-3).

More concern of asynchronous authorizations is on the LLP of GM maize in recent years. As shown in Table 3, there are 29 and 11 GM events of maize have been approved by USA and Argentina, the two largest maize exporting countries in the world. However, among those approved in USA, only 11 events have been approved in China. Although the number is same, the events approved in China and Argentina are quite different. Only 7 events are approved both in China and Argentina. Just as discussed above, the asynchronous authorizations on GM events would undermine international trade with great potentials. Such a concern has happened in China. For example, there was about 5.4 tons of genetically modified (GM) maize imported from the United States refused by China on Nov. 2010 because the unapproved GM event of MON89034 was found in the corn. The biotech industry now is more concern on asynchronous authorizations of Agrisure Viptera™ (OECD Identifier: SYN-IR162-4) that has been approved in USA for commercial cultivation but still undergoing approval process in China in 2011.

There are only few GM events of rice approved by countries. As shown in Table 4, there are 10 GM events available worldwide by 2011, only 4 events have been approved and no country claims that these GM rice events have been commercially cultivated for food and feed uses, which reflects cautious attitudes to rice, the largest staple food crops in the world. Meanwhile, it also indicates that China, a rice exporter, plan to commercially produce the GM rice should seriously consider whether China should pursue its GM rice events approvals in its major trade partners, otherwise the LLP and rice trade disruption are very likely to occur in future.

2.3 A summary of key biosafety regulation issues related to trade

Based on previous discussions on China's biosafety regulation and process, there are 2 major concerns and several minor issues related to trade. Such the regulations would not only raise the cost of trade, more importance but also the LLP of GMOs and trade disruption.

Two major issues are asynchronous authorization and a zero tolerance rule. According to China's biosafety regulation on GM import, foreign institutions or companies must submit the related certificate of biosafety approvals from the original country to BMO, that is, biosafety regulation process of import for any GM event can be started only after the event has been approved in the original country. It will at least take about 2-3 years to go through all 7 procedures and certain risk assessments, as discussed above, before getting the final permission. Obviously, the asynchronous authorization between exporting countries and China will create the high risk of LLP and delay of trade.

A zero tolerance rule further puts high risk on GMO trade. Currently, China adopts the regulation of zero tolerance level for unapproved GM products. It means that any product imported would be refused if unapproved events were detected. Combined with the asynchronous authorization of GM events between exporting countries and China, the zero tolerance is likely to have significant trade implication.

Besides the above two major issues, there are other three aspects that also generate additional costs to trade. They are biosafety regulation cost, import test cost, and personal (staff time) cost. Biosafety regulation and import test cost are direct costs and can be easily measured, the costs related to personal time spent on getting the GM events and import permission are not easy to be quantified.

3. Trade on GM rice, maize and soybean

To estimate GM product traded, the GM/non-GM commodities are classified by the country whether it produces the GM products or not. The commodities are defined as GM (or more accurately potential GM) if it is imported from GM producing countries, or else they will be defined as non-GM.

There are three commodities included in China's case study. They are maize (HS100590 and HS100510), soybean (HS120100) and rice (HS100610, HS100620, HS100630 and HS100640). All trade data are from the UN Comtrade database in 996 to 2010. As to the characteristic of trade, we focus the China's import of two commodities (i.e., soybean and maize) and export of rice.

China’s soybean import is dominated by exporting countries with GM production. As shown in Figure 2, the three overwhelming exporters of soybean to China are USA, Brazil and Argentina. For example, China’s import 54.8 million tons (or 25.1 billion US dollar) of soybean in 2010, which was about 3.7 times of domestic production in the same year. The import quantity shares from USA, Brazil and Argentina were 43.1%, 33.9% and 20.4%, respectively, in 2010. Because USA, Brazil and Argentina are the world top 3 largest GM soybean producing countries, based on the definition of GM and non-GM soybean in this study, almost all the imported soybeans by China are GM products. As shown in Figure 3, import of non-GM soybean accounted for very small share during 1996-2010. In 2010, GM soybean accounted for 97.4% in total import, while non-GM soybean import was only 2.6% of total China’s soybean import.

Similarly, China’s import of maize is also dominated by GM varieties. China used to be a net exporter of maize in 2000-2009, with annual average net export of 6.36 million tons (NSBC, 2010). However, China’s export of maize has declined rapidly, especially in recent years because of fast rising demand for feed and processing uses in China. In 2010, China has reversed to be a net importer and imported 1.57 million tons of maize (Figure 4). Based on our recent projection, it is expected that China’s import of maize would rise further in future (Huang et al., 2010). Meanwhile, USA is the dominated exporter of maize to China. As shown in Figure 4, there was 1.5 million tons of maize imported from USA, accounted for 95.5% percent of total import in 2010.[2] Moreover, USA is also world largest GM maize producing countries. Consequently, the majority of maize imported by China is GM maize.

There is a declining trend of rice export from China, and the export only takes about 1 percentage of domestic production. As shown in Figure 5, while the export value fluctuates in 1996-2010, there is an overall declining trend of export quantity after 1998. The export has dropped from 3.74 million in 1998 to 0.62 million tons in 2010

[2] China also imported maize DDGS (distiller's dried grains) about 2 million metric tons for feed use from USA in 2010.

(Figure 5). Meanwhile, the export share to total production also shows declining trend from historical peak of 2.7% in 1998 to only 0.4% in 2010.

It is noteworthy that Japan and South Korea took quite large share of China's rice export in recent years (Figure 5). For example, the export of rice to Japan and Korean accounted for 44.0% in value term and 37.0% in volume term of China total rice export in 2010. As the consumers in Japan and Korea are used to hold the adverse opinions to GM food (Magnusson & Hursti, 2002; McCliskey & Wahl, 2003) and China has not tried for approval of it GM events in the rest of world, the commercial production of GM rice in China is likely to confront high risk and even face the import ban in the future.

4. Methodology and scenarios

To understand likely trade and economic implications of LLP and asynchronous authorizations of agricultural biotechnology varieties, the Global Trade Analysis Program (GTAP) is adopted. GTAP is a well known multi-country, multi-sector computable general equilibrium model, and is often used for international trade analysis (Hertel, 1997). The model is based on the assumptions that producers minimize their production costs and consumers maximize their utilities subject to a set of certain common constraints. Supplies and demands of all commodities clear by adjusting prices in perfectly competitive markets. Representative consumers of each country or region are modeled as having a non-homothetic Constant Difference of Elasticity (CDE) demand function. On the production side, firms combine intermediate inputs and primary factors (e.g., land, labor, and capital) to produce commodities with constant-return-to-scale technology. Intermediate inputs are composites of domestic and foreign components, with the foreign component differentiated by region of origin (the Armington assumption).

We use version 7 of the GTAP database in this study. The standard GTAP database includes 57 sectors of which 20 represent agricultural and processed food sectors. Despite the relatively high level of disaggregation, many of the key commodities for this study (i.e., maize and soybean) are aggregated with other crops. For example, maize is aggregated with other coarse grains and soybean is part of a broader oilseeds category. Therefore, we spilt the key commodities (i.e., maize and soybean) from the broad categories where they currently reside so that they are represented explicitly in the model database. For example, we disaggregate maize from coarse grains along with soybeans from oilseeds using a "splitting" program (SplitCom) developed by Horridge (2005). In making the split, we used trade data from the United Nations Commodity Trade Statistics Database (UNCOMTRADE) and production and price data from the FAO.

Meanwhile, we simulated the economy to 2015 to reflect the potential impact of LLP. Because the current latest GTAP database is in 2004, we adopt the recursive dynamic method to update the GTAP data from 2004 to 2010 and projected to 2015. During the updating process, the growth rates of GDP, population, capital and labors in different regions are given exogenous. The information is calculated based on database from World Development Index (WDI) developed by World Bank, International Monetary Foundation (IMF) and International Labour Organization (ILO). Such a method has been popularly used by many similar researches (Walmsley et.al 2000; Meijl et al. 2002; Tongeren et al. 2004）. Meanwhile, the important known trade liberations, especially related to China, are also considered. For example, the further tariff reduction according to China's WTO commitments, elimination of MFA (Multi-Fiber Arrangement), and Free Trade Agreement (FTA) between China and ASEAN countries etc.

In China's case study, four scenarios are designed to simulate the impacts on the production, trade and price of key commodities in China and main trade partners. They include one reference scenario and three alternative scenarios, one for China's rice export and the other two for China's imports of maize and soybean (Table 5). Under the reference scenario, it is assumed no effect of LLP on trade and the global trade running as usual. For import of GM maize and soybean, we did not make effort to estimate the probability of imported GM maize or soybean refused at China's boarder due to the events of LLP for unauthorized agricultural biotechnology varieties. But we formulate two alternative scenarios, one lower refused import and the other higher refused import scenarios, to see a range of likely impacts. The assumptions of three policy scenarios are briefly discussed below.

1） Ban on China's rice export. As shown in Table 4, only China has approved the events of Bt Shanyou 63 and Huahui 1. If China commercially produces GM rice without the GM event approved in its major rice trade partners, it is very likely that China's rice export could be banned. This scenario tries to capture impacts on China's agricultural production, under the extreme circumstance that all trade partners banned rice import from China.

2） Lower refused rate of LLP for unapproved GM maize and soybean exported to China. It is assumed the lower refusals on import of GM maize and soybean from GM producing countries by China's GM product import regulation. The import of maize and soybean from GM producing countries to China would be reduced by 10% and 5%, respectively, relative to reference scenario in 2015:

— Reducing maize import by 10% (M-10%).

— Reducing soybean import by 5% (S-5%).

We assume a relatively higher refused rate for maize import (10%) than soybean (5%) for several reasons. Normally, GM soybean events are relatively less in soybean than maize. China has experienced more than 10 years of large GM soybean import, there was no a single soybean shipment was refused due to LLP of unapproved GM soybean in the past. For maize, LLP of unapproved GM maize occurred in 2010 and this is likely to occur in the coming years as we discussed in the previous section.

3） Higher refused rate of LLP for unapproved GM maize and soybean exported to China. Similarly, we assume two different refused rates for soybean and maize. The import of maize and soybean from GM producing countries to China would drop by as high as 50% and 10%, respectively, relative to reference in 2015:

— Reducing maize import by 10% (M-50%).

— Reducing soybean import by 5% (S-10%).

5. Likely impacts of LLP on trade flow and food prices

Likely trade and economic implications of LLP and asynchronous authorizations of agricultural biotechnology are complicated. The impacts could be in both the short term and the long term. Some short term impacts are not easy to quantify. For example, when import of GM commodities is rejected at boarder of importing country at large volume, domestic market might not be able to response with increase in supply (e.g., production and storage) in short period, in this case, the impacts would be much large than the results presented in this section as the estimated impacts in this study include only the impacts under a market that can effectively response with import shock. For this reason, we should consider the results are downward bias for each scenario simulated in this study. Some other impacts are also not examined this study. These include disruption and problems in making trade arrangement due to perceived risk of shipping GM maize and soybean to China, costs to exporters when unauthorized GM maize and soybean have to be shipped back the original country or transferred to the third county.[3]

With the above notes, the rest of this section presents the results that reflect a long term impacts of LLP of unauthorized GM rice, maize and soybean in China's trade under three scenarios.

Ban on China's rice export

Simulation results show that ban on China GM rice export is not likely to have large impacts on China's rice as well as while economy. As shown in Table 6, when other countries ban China's GM rice export, the domestic price and production drops by -0.32% and -0.45%, respectively, relative to reference scenario in 2015. As to the lower domestic rice price, the import will also decline a little bit (-2.79%). Such a result is easily understood with considering the very small ratio (less than 1% in 2015) of rice export to total rice production in China. Although the total effect is small, it is noteworthy the effects of relocation of production resources. Because the production resources (labor, capital and land) will shift to other sectors from rice, the price of other sectors will drop a little bit and their productions will rise relative to reference scenario (Table 6). Meanwhile their export will increase and import will decline as the rising competitiveness (i.e., lower price). As a whole, the social economic welfare in China will drop by about 4.0 million US dollar comparing to reference scenario in 2015.

Lower and higher refused rates of importing maize and soybean

[3] Some traders claimed that the risks and costs associated with LLP of unauthorized GMOs are enormous, however, no empirical study on this topic has been published so far. Obviously, this is an interesting area that needs further study.

The maize production in China will increase slightly, but it is at the cost of other agricultural sectors. As shown in Table 7, if the maize import is reduced by 10% relative to reference in 2015, the domestic price of maize will rise by 0.26% and the domestic production increases 0.62%. However, the rising production of maize needs more inputs and competes with other sectors for production resources. Consequently, the price other sector will increase for the rising cost and their production will drop correspondingly (columns 2 and 3, Table 7). The import of other agricultural commodities will also increase as the less competiveness (column 1, Table 7).

Impacts will get much larger if the maize import was reduced by 50% (i.e., M-50% scenario). Under this scenario, the price and production of maize will be increased by 1.42% and 3.25%, respectively, in 2015 (row 2, column 5-6, Table 7). However, the production of other crops and livestock will drop much significantly, with rising dependence on world market to meet their demands. Meanwhile, the social welfare under M-10% and M-50% will be reduced by 4.0 and 56 million US dollar due to the lower economic efficiency.

However, the countries producing the unapproved events of GM maize in China will confront the reduction of export. As shown in Table 8, the maize export of USA will drop by 0.59% and 3.0%, respectively, under M-10% and M-50%. The lower global market opportunity will cause the shrinking in production. The maize production in USA will decline by 0.18% and 0.9%, relatively to reference scenario in 2015 (column 2, Table 8). Similarly to the case of China's GM rice, the adjustment of production will also be found among agricultural sectors. Although such an effect may offset the negative impacts led by the LLP issue, the maize sector in USA will be hurt with no doubt, especially under the situation of higher refused rate.

The impacts on China's soybean production and price are remarkable, even with much lower rate of import reduction. As shown in Table 9, the soybean price and production in China will rise by 7.87 and 16.46% if the import from GM soybean reduces by 5%. It will increase further under the situation of high refused rate. The soybean price and production will rise by 18.01 and 37.03% if the import from GM soybean reduces by 10% (column 5 and 6 of table 9). The much higher impact on soybean with lower refused rate of import is because of its large import volume. According to the results in reference scenario, China's import of soybean will continue increasing in future and it will reach about 65 million tons in 2015. Moreover, the domestic production of soybean is much smaller relative to the import. It is about 17 million tons in 2015, just 26% (one quarter) of import. Therefore, even with quite small reduction rate of import, it will have significant impacts on domestic soybean market and price.

The rising production of soybean is also at the cost of other crops and livestock sectors. Their prices will increase, conversely, the productions will drop. Meanwhile, the import of those commodities will also increase because of the rising price (columns 2 and 4, Table 9). The social welfare in China will decline by 18 and 191 million US dollar in the scenarios of S-5% and S-10%, comparing to the reference scenario in 2015.

Similarly, the countries producing the GM soybean with unapproved events in China will confront the challenge of reduction of export and production. As shown in Table 10, the export of soybean from the three dominate exporters, USA, Brazil and Argentina, will drop 1.75%, 1.80% and 3.37%, respectively, under the scenario S-5% in 2015. Furthermore, the falling extent in exports of these three countries will be much more severer (3.57%, 3.65% and 6.78%, respectively) under the scenario of S-10%. Because of the shrinking export, the domestic production of soybean will also decline significantly in these three countries. The production of soybean in USA, Brazil and Argentina will fall by 0.85%, 1.01% and 0.69% under scenario S-5%, and by 1.73%, 2.04% and 1.42% under scenario S-10% (row 11, Table 10).

6. Conclusions

China has developed its own and strong biotech program and corresponding biosafety regulation system for GM commercial production and import. China considers that GM technology is an important technology that can increase its agricultural productivity and help China to meet its growing demand for food, feed and fiber in the rapid growing economy.

While China has been developing its own biotech for use in domestic production, it has not started to seek for approval of its GM events in any foreign country. This may be explained by the fact that China's biotech program is aimed to improve domestic agricultural productivity and national food security. Even for exportable products such as rice, as the export is very limit, the expected impacts of LLP of unauthorized GM rice in the rest of world will be minimal.

However, as China continues to expand its biotech crop commercialization, despite the impacts on China's agricultural trade might be not significance, the trade conflicts between China and its exporting destination countries could rise overtime. Therefore, if China wants to minimize the risk of disruption of trade resulted from LLP and also create the good external environment of development of GM technology, China may consider whether or not to seek for approval of its GM events in its major export destination countries in the future.

China's biosafety regulations on biotech crop import, started import application after approval from the original country and a zero tolerance rule, will have important implications to USA, Brazil and Argentina on maize and soybean production and its export to China. With considering the huge and rising market opportunities for soybean and maize, it will very crucial for those countries that are exporting or potentially export large quantities of two commodities to China should pay attention to China's regulations on GM product imports. Likely trade and economic implications of LLP and asynchronous authorizations of agricultural biotechnology are significant. The disruption of trade on maize and soybean caused by LLP will generate negative impacts on production, price and trade of those main trade partners of China.

Meanwhile, it is also worthwhile for Chinese government to consider the negative effects on its agriculture, food price and economic welfare. Although it some sense, it provides certain protections on those commodities, there is trade-off between food supply, food price and social welfare induced by biosafety regulation on GM import. A less trade distorted regulations on LLP can take advantage of comparative advantage of agricultural production, stabilize domestic food price, and increase total social welfare.

Moreover, there might be a win-win scenario by finding pragmatic policy solutions that seek to ensure the health and safety of imported commodity shipments and to minimize disruptions to international trade without overly burdensome costs. Therefore, the further global cooperation and multilateral information sharing mechanism should be set up to enhance the safety management and also lower the multifarious and unnecessary costs of LLP.

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Table 1. Status of biotech plants in China in 2010.

Crops	Small field trial	Enlarged field trial	Pre-production trial	Safety certificate for production
Cotton	√	√	√	√
Rice	√	√	√	√
Maize	√	√	√	√
Tomato	√	√	√	√
Sweet pepper	√	√	√	√
Papaya	√	√	√	√
Poplar trees	√	√	√	√
Petunia	√	√	√	√
Wheat	√	√	√	No
Soybean	√	√	√	No
Rapeseed	√	√	√	No
hot pepper	√	√	√	No
Potato	√	√	No	No
Peanut	√	√	No	No
Cabbage	√	√	No	No
Sweet melon	√	No	No	No

Source: Authors' survey.

Table 2: GM soybean events approved by USA, Brazil and China by July 2011

	USA	Brazil	China
Roundup Ready™ (OECD Identifier: MON-Ø4Ø32-6)	Yes	Yes	Yes
Genuity Roundup Ready 2 Yield™ (OECD Identifier: MON-89788-1)	Yes	Yes	Yes
LibertyLink™ (OECD Identifier: ACS-GMØØ5-3)	Yes	Yes	Yes
LibertyLink™ (OECD Identifier: ACS-GMØØ6-4)	Yes	Yes	No
Cultivance™ (OECD Identifier: BPS-CV127-9)	No	Yes	No
Optimum™ GAT™ (OECD Identifier: DP-356Ø43-5)	Yes	No	No
TREUS™ (OECD Identifier: DP-3Ø5423-1)	Yes	No	No
MON87701 (OECD Identifier: MON-877Ø1-2)	Yes	Yes	No
MON87705 (OECD Identifier: MON-877Ø5-6)	Yes	No	No
DuPont (lines: DD-Ø26ØØ5-3, DD-Ø26ØØ5-3, DD-Ø26ØØ5-3)	Yes	No	No
LibertyLink™ (OECD Identifier: ACS-GMØØ4-2)	Yes	No	No
LibertyLink™ (lines: ACS-GMØØ2-9, ACS-GMØØ1-8)	Yes	No	No
LibertyLink™ (OECD Identifier: ACS-GMØØ3-1)	Yes	No	No

Source: Eurofins GeneScan

Table 3. GM maize events approved by USA, Argentina and China by July 2011

	USA	Argentina	China
Agrisure CB Advantage™, Agrisure™ CB/LL (OECD Identifier: SYN-BTØ11-1)	yes	Yes	Yes
KnockOut™, NatureGard™ (OECD Identifier: SYN-EV176-9)	yes	Yes	Yes
Roundup Ready™, Agrisure GT™ (OECD Identifier: MON-ØØØ21-9)	yes	Yes	Yes
Herculex I™ (OECD Identifier: DAS-Ø15Ø7-1)	yes	Yes	Yes
Herculex RW™ (OECD Identifier: DAS-59122-7)	yes	No	Yes
LibertyLink™ (OECD Identifier: ACS-ZMØØ3-2)	yes	yes	Yes
Agrisure RW™ (OECD Identifier: SYN-IR6Ø4-5)	yes	No	Yes
YieldGard™, MaizeGard™ (OECD Identifier: MON-ØØ81Ø-6)	yes	yes	Yes
YieldGard Rootworm™, MaxGard™ (OECD Identifier: MON-ØØ863-5)	yes	No	Yes
Roundup Ready 2™ (OECD Identifier: MON-ØØ6Ø3-6)	yes	yes	Yes
LibertyLink™ (OECD Identifier: DKB-8979Ø-5)	yes	No	Yes
YieldGard VT RW™ (OECD Identifier: MON-88Ø17-3)	yes	yes	No
YieldGard VT Pro™ (OECD Identifier: MON-89Ø34-3)	yes	yes	No
Enogen™ (OECD Identifier: SYN-E3272-5)	yes	No	No
Optimum™ GAT™ (OECD Identifier: DP-Ø9814Ø-6)	yes	No	No
Mavera™ (OECD Identifier: REN-ØØØ38-3)	yes	No	No
Agrisure Viptera™ (OECD Identifier: SYN-IR162-4)	yes	No	No
MON87460 (OECD Identifier: MON-8746Ø-4)	yes	No	No
Bt-Xtra™ (OECD Identifier: DKB-89614-9)	yes	yes	No
LibertyLink™ (OECD Identifier: ACS-ZMØØ2-1)	yes	yes	No
StarLink™ (OECD Identifier: ACS-ZMØØ4-3)	yes	No	No
YieldGard™ (OECD Identifier: line: MON801)	yes	No	No
YieldGard™ (OECD Identifier: MON-8Ø2ØØ-7)	yes	No	No
MON809 (OECD Identifier: PH-MON8Ø9-2)	yes	No	No
Roundup Ready™ (OECD Identifier: line: MON832, MON831, MON830)	yes	No	No
SeedLink™ (OECD Identifier: ACS-ZMØØ1-9)	yes	No	No
SeedLink™ (OECD Identifier: ACS-ZMØØ5-4)	yes	No	No
Pioneer MS (OECD Identifier: PH-ØØØ676-7, PH-ØØØ678-9, PH-ØØØ68Ø-2)	yes	No	No
TC 6275 (OECD Identifier: DAS-Ø6275-8)	yes	No	No

Source: Eurofins GeneScan

Table 4. GM rice events approved by country by 2011.

Events of GM Rice	Approved by countries
LibertyLink™ (ACS-OSØØ1-4, ACS-OSØØ2-5)	Australia, Canada, Japan, Mexico, Russia, USA
LLRice601 (line: LLRice601)	Colombia, USA
LLRice604 (LLRice604)	-
Bt Shanyou 63, Huahui 1 (line: T51-1)	China
KMD1 (TR30)	-
KeFeng6 (Event 166)	-
Tararikhteh (line: B827)	Iran
PE-7 (PE-7)	-
Golden Rice (GR2-G, GR2-E, GR2-L, GR2-R, GR2-T, GR2-W)	-
Golden Rice (GR1-309, GR1-146, GR1-652)	-

Source: Eurofins GeneScan

Table 5. Three policy scenarios used to simulate the impacts of LLP.

Scenarios	Rice export	Maize import	Soybean import
Ban on China's rice export	-100%		
Lower refuse rate for LLP			
M-10%:		-10%	
S-5%:			-5%
Higher refuse rate for LLP			
M-50%:		-50%	
S-10%:			-10%

Table 6. Impacts on production, price and trade of China's agricultural commodities under ban on China's rice export scenario, relative to baseline (%, 2015)

	Production	Price	Export	Import
Rice	-0.45	-0.32	-100.00	-2.79
Maize	0.01	-0.03	0.12	-0.04
Soybean	0.04	-0.03	0.16	0.00
Other crops	0.03	-0.03	0.13	-0.06
Beef & mutton	0.02	-0.03	0.30	-0.10
Pork & poultry	0.02	-0.04	0.35	-0.12
Milk	0.04	-0.03	0.25	-0.08
Processed food	0.02	-0.03	0.00	-0.08

Table 7. Impacts on production, price and trade of China's agricultural commodities under M-10% and M-50% scenario, relative to baseline (%, 2015)

	M-10%			M-50%		
	Import	Price	Production	Import	Price	Production
Rice	0.12	0.02	0.00	0.64	0.12	0.00
Maize	-10.0	0.26	0.60	-50.0	1.42	3.25
Soybean	0.01	0.02	-0.04	0.04	0.1	-0.23
Other crops	0.05	0.03	-0.02	0.27	0.14	-0.11
Beef & mutton	0.16	0.05	0.00	0.86	0.25	-0.02
Pork & poultry	0.06	0.02	-0.01	0.34	0.12	-0.04
Milk	0.30	0.12	-0.11	1.57	0.64	-0.58
Processed food	0.01	0.01	0.00	0.07	0.04	-0.02

Table 8. Impacts on production and trade of USA agricultural commodities under M-10% and M-50% scenario, relative to baseline (%, 2015)

	M-10%		M-50%	
	Export	Production	Export	Production
Rice	0.04	0.02	0.20	0.09
Maize	-0.59	-0.18	-3.00	-0.90
Soybean	0.03	0.02	0.17	0.09
Other crops	0.05	0.02	0.23	0.12
Beef & mutton	0.06	0.01	0.29	0.03
Pork & poultry	0.03	0.01	0.18	0.03
Milk	0.09	0.00	0.46	0.02
Processed food	0.00	0.00	0.02	0.00

Table 9. Impacts on production, price and trade of China's agricultural commodities under S-5% and S-10% scenario, relative to baseline (%, 2015)

	S-5%			S-10%		
	Import	Price	Production	Import	Price	Production
Rice	0.28	0.06	-0.01	0.67	0.15	-0.04
Maize	0.71	0.15	-0.02	1.63	0.37	-0.10
Soybean	-5.00	7.87	16.46	-10.00	18.01	37.03
Other crops	0.13	0.14	-0.10	0.31	0.34	-0.26
Beef & mutton	0.20	0.07	-0.10	0.41	0.16	-0.22
Pork & poultry	0.51	0.21	-0.07	1.09	0.45	-0.17
Milk	0.13	0.11	-0.21	0.29	0.26	-0.47
Processed food	0.50	0.36	-0.18	1.11	0.82	-0.42

Table 10. Impacts on trade and production of USA, Brazil and Argentina agricultural commodities under S-5% and S-10% scenario, relative to baseline (%, 2015)

	S-5%			S-10%		
	USA	Brazil	Argentina	USA	Brazil	Argentina
Impacts on Export						
Rice	0.17	0.90	-0.04	0.35	1.83	-0.05
Maize	0.10	0.46	0.00	0.22	0.93	0.01
Soybean	-1.75	-1.80	-3.37	-3.57	-3.65	-6.78
Other crops	0.14	0.37	0.10	0.30	0.76	0.22
Beef & mutton	0.08	0.39	0.05	0.16	0.78	0.13
Pork & poultry	0.16	0.37	0.11	0.34	0.75	0.24
Milk	0.11	0.54	0.03	0.23	1.10	0.06
Processed food	0.09	0.34	0.09	0.21	0.69	0.19
Impacts on Production						
Rice	0.08	0.08	0.01	0.16	0.17	0.03
Maize	0.06	0.21	-0.01	0.13	0.42	-0.02
Soybean	-0.85	-1.01	-0.69	-1.73	-2.04	-1.42
Other crops	0.07	0.11	0.03	0.16	0.23	0.10
Beef & mutton	0.02	0.10	0.00	0.04	0.21	0.01
Pork & poultry	0.03	0.19	0.01	0.06	0.38	0.03
Milk	0.01	0.03	0.01	0.02	0.06	0.01
Processed food	0.02	0.07	0.02	0.03	0.15	0.04

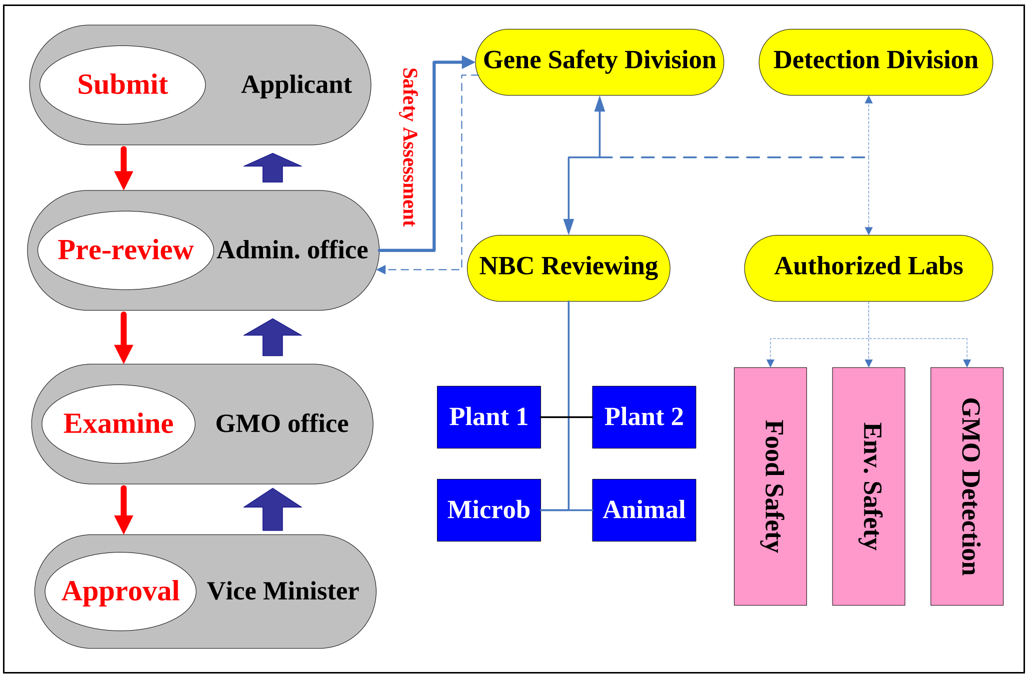

Figure 1. Regulatory process for import of GM products in China.

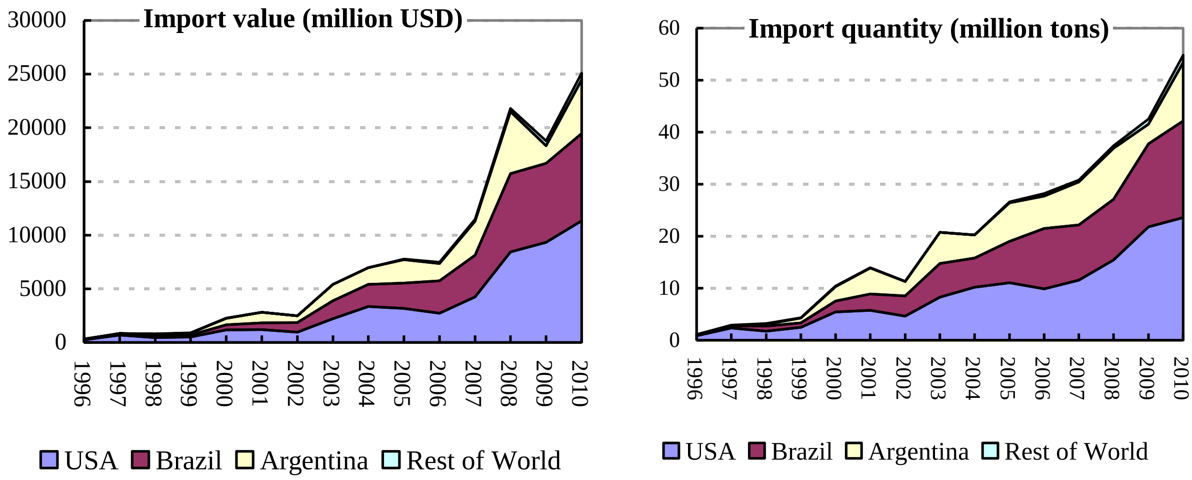

Figure 2. Import of soybean in China, 1996-2010.

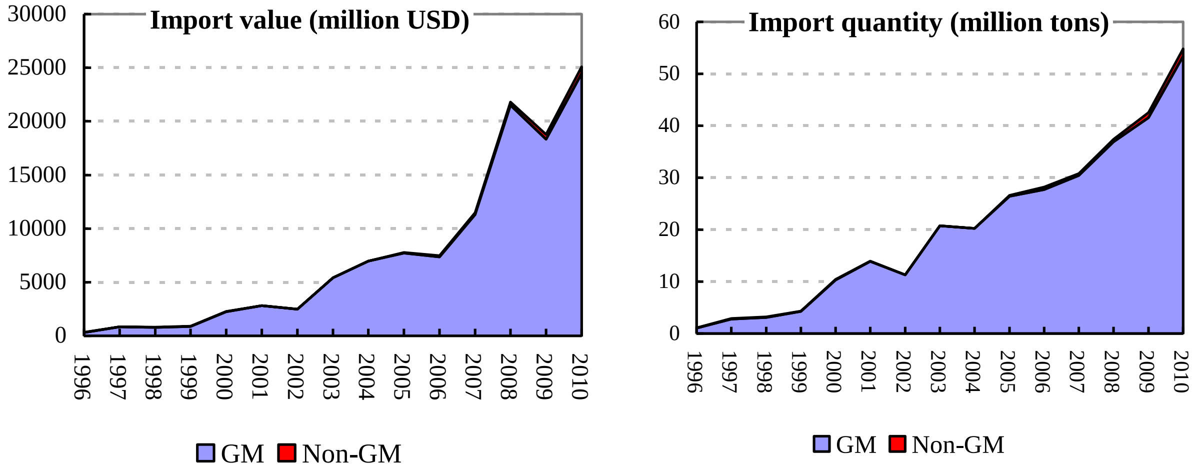

Figure 3. The import of GM and non-GM soybean in China, 1996-2010.

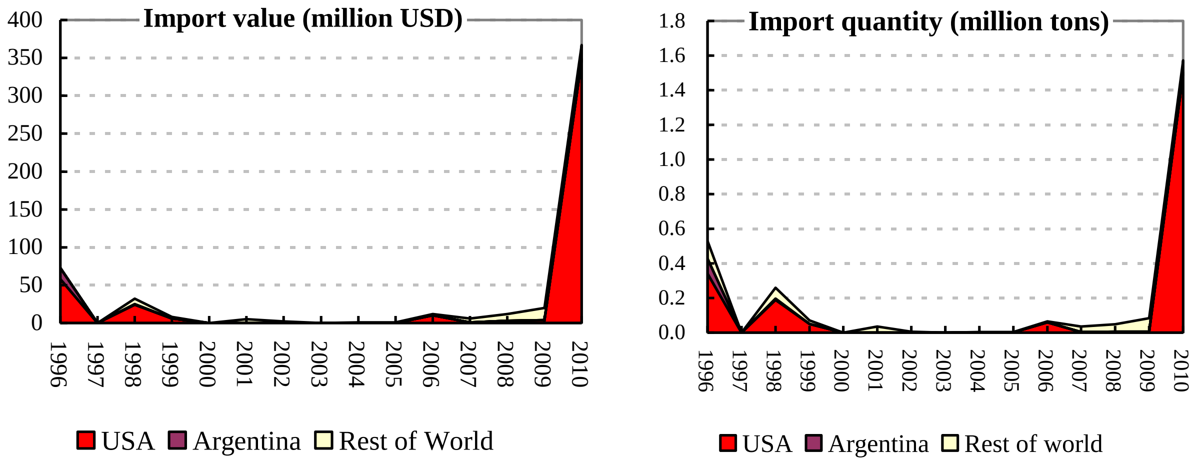

Figure 4. Import of maize in China in 1996-2010.

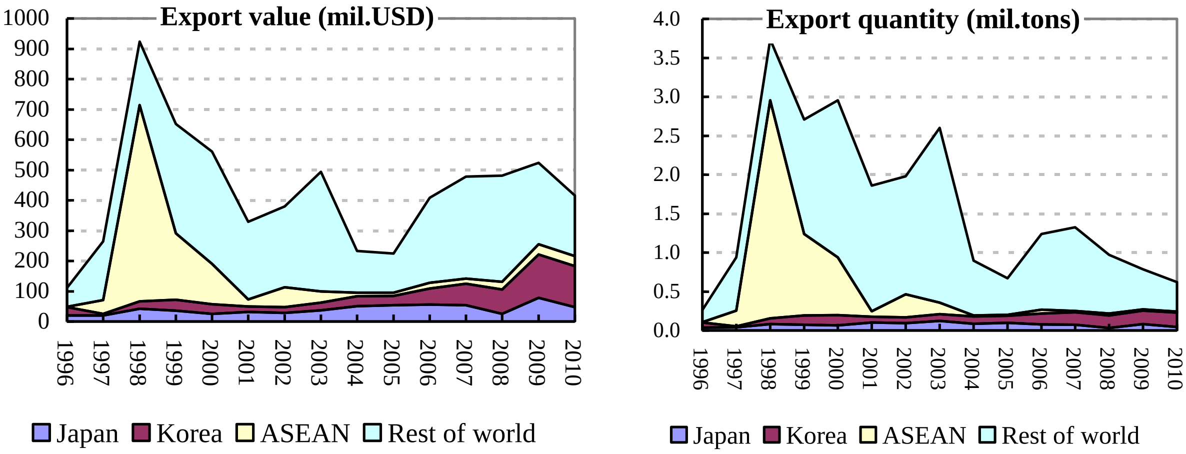

Figure 5: the export of rice from China during 1996-2010