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China's Agricultural Biotechnology Regulations—Export and Import Considerations

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

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Abstract

China has a biosafety regulatory framework in place for both domestic GM crop commercialization and imports. China imported about four times as many soybeans as it produced domestically in 2010 and is also expected to become a major importer of maize in the near future. Both China's soybean and maize imports are dominated by GM varieties, with most soybean imported from the US, Brazil and Argentina and maize imported mainly from the US.

China's import approval process takes on average 2-3 years, and can only commence when a submitter for import approval has already received full regulatory approval in their country of origin, resulting in significant asynchronicity (for maize, for example, only 11 out of some 29 GM events authorized in the US had been approved in China by late 2010). The China paper indicates that trade disruptions due to China's zero threshold approach to LLP could result in a slight increase in domestic maize price and large rise in soybean price, with knock-on effects on the livestock sector and overall social welfare, and also have repercussions in the export markets.

The paper also points out that although China has commercialized several GM crops and has a significant number in the research and regulatory pipeline, it has so far not opted to seek approval of its GM crop events in any foreign country. This could lead to trade disruptions affecting Chinese rice exports, although these exports are declining, but also growing exports of processed rice products.

Key China recommendations include:

- Soy and maize exporters are well advised to pay close attention to Chinese import approval regulations.

- China should consider embarking on its import approval process before a GM event has been authorized in the country of origin, so as to shorten the regulatory delay.

- China should also take a pragmatic and cost-effective approach to LLP that ensures the safety of imported commodity shipments and minimized disruptions to international trade and domestic market price stability.

- Although China's biotech program is focused on improving its domestic agricultural productivity and food security, it should nonetheless request approvals in trade partners, in order to avoid import bans affecting its rice and processed rice products.

1. Introduction

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

China ranks among the major countries with a strong biotech program. China's modern biotech program has grown into the largest initiative in the developing world. Chinese leaders and leading scientists view GM technology as an important tool to boost agricultural productivity and improve national food security. Public investment in biotech crops and livestock has doubled every 3-4 years over 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 for 2009-2020, focusing on GM rice, wheat, maize, cotton, soybean, pig, cattle and sheep.

China has also commercialized several biotech crops since 1997. By 2006, China had approved the commercialization of biotech GM cotton, petunia, tomato, sweet pepper, poplar trees and papaya. Bt cotton is the Chinese biotech program's biggest success story: by 2009, it was cultivated on 3.7 million hectares, accounting for 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 for Bt rice and phytase maize and there are also several other biotech crops in the pipeline. Biosafety approval for biotech rice and maize – major food and feed crops - represent a major milestone in China's biotech development which is expected to have significant implications for biotech development in the rest of world and for 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. Additional 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 a comprehensive biosafety regulation and monitoring system for both domestic GM crop commercialization and GM crop imports. 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 developed by China's own biotech programs and there are also a significant number of GM crop events in the R&D and regulatory pipeline, China has not started to seek approval for its GM crop events in any foreign country. Exporters of Chinese commodities, particularly rice and processed rice food exporters, have started to express concern that China's current policy of seeking only domestic approval for GM crops could lead to trade disruptions resulting from low level presence (LLP) of GM events not approved in the importing country in Chinese exports of commodity shipments and processed foods.

On the import side, China's regulatory system provides for case-by-case authorizations for import. China has been importing GM soybeans and soybean oil for more than 10 years and is considered the largest biotech soybean importer. Recently, China has shifted from being a net maize exporter to a net importer, and has also imported GM maize.

China's agricultural import biosafety regulations require that import approval requests can only be launched after the event has been approved in the exporting countries, leading to significant asynchronicity of approvals. Since China has a zero tolerance policy for unapproved GM products, exporters and biotech companies from the US and other countries have raised concerns about potential disruptions to trade.

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 this case study. China has been a major rice exporter with average annual exports of about 1.5 million tons in the past 2 decades (NSBC, 2010). Although its exports declined in recent years, Chinese exports of processed rice foods have been rising (Wang 2009). Imports of biotech soybeans have significantly increased and reached 54 million metric tons in 2010 (NSBC, 2011). In 2010, China imported 2 million tons and 3 million tons of maize and dried distillers grains (DDG, by-products of ethanol production from maize) respectively. (FeedTrade, 2011). Although China has only begun importing maize in recent years, maize imports are expected to continue rising in the future (Huang et al., 2010).

This paper is organized as follows: Section 2 discusses China's authorization procedure for agricultural biotech products, with a special focus on import approvals, and examines GM products in China's pipeline. Section 3 provides an overview of China's trade of rice, maize and soybeans and assesses the likelihood of LLP of biotech crops in both China's imports and exports. Section 4 presents the methodology and scenarios for the model used in this case study and section 5 shows the modeling results on the likely 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

An overview of China's biosafety regulation

In response to the emerging agricultural biotechnology, China established and improved its legal and regulation system for agricultural biosafety since the early 1990s. The first biosafety regulation, "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 plants, animals and microorganisms. The Implementation Measures provided detailed biosafety regulation procedures for 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 the continued development of agricultural biotechnology, rising GMO imports and in response to 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 national "Regulation on the Safety Administration of Agricultural Transgenic Organisms," includes trade regulation and labeling of GM farm products, which became effective after May 23, 2001. Based on this new regulation, the MOA issued three implementing regulations on biosafety management, trade, and labeling of GM products that became effective after March 20, 2002.

These amended regulations from 2002 encompassed trade and labeling of GM products, and were promulgated in response to rising imports of GM products, particular GM soybean and edible oils, and the growing presence of GM foods in the market. These regulations established a "zero tolerance level for unapproved GM products" in both import and labeling. Labeling requirements now pertain to 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. Detailed regulations and procedures for GM product import approval authorizations have also been developed and implemented since 2002 (see more discussion in the later part of this section.)

The MOA is the primary institution in charge of implementing the agricultural biosafety regulations. The governing body under MOA is the Leading Group on Agricultural GMO Biosafety Management, which oversees the Agricultural GMO Biosafety Management Office (BMO). The biosafety assessments are conducted by the National Agricultural GMO Biosafety Committee (BC). Currently, the BC meets 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. The BC undertakes biosafety assessments. Based on the BC's technical assessments and other considerations (e.g., social, economic and political factors), the BMO prepares the recommendations to the MOA's Leading Group which is tasked with taking approval or disapproval decisions.

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	Yes	Yes	Yes	Yes
Rice	Yes	Yes	Yes	Yes
Maize	Yes	Yes	Yes	Yes
Tomato	Yes	Yes	Yes	Yes
Sweet pepper	Yes	Yes	Yes	Yes
Papaya	Yes	Yes	Yes	Yes
Poplar trees	Yes	Yes	Yes	Yes
Petunia	Yes	Yes	Yes	Yes
Wheat	Yes	Yes	Yes	No
Soybean	Yes	Yes	Yes	No
Rapeseed	Yes	Yes	Yes	No
Hot pepper	Yes	Yes	Yes	No
Potato	Yes	Yes	No	No
Peanut	Yes	Yes	No	No
Cabbage	Yes	Yes	No	No
Sweet melon	Yes	No	No	No

Source: Authors' survey

Pursuant to the biosafety regulations, MOA has approved a number of biotech events for commercial production or field trials; by 2010, MOA had issued biosafety certificates for production of 8 plants (Table 1).[1] In the meantime, MOA has also issued biosafety certificates for field trials or pre-production trials for wheat, soybean, rapeseeds and other crops (Table 1).

It is interesting to note that despite the increase of biotech approvals by MOA, China has not made efforts to seek approval for these GM crops in other countries. This may be due to the fact that, among approved events (Table 1), Bt cotton is the only crop that has been widely adopted by farmers. Since the goal of China's biotech program is to improve domestic agricultural productivity and national food security, China may also not believe it necessary to seek approval in foreign countries. 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 express concerns that China's policy of seeking only domestic approval of GM crops could lead to LLP of GM events not approved in other countries in China's exports. It was reported that rice products exported from China to the EU contained an illegal GM event, Bt Shanyou 63 (Terra Daily, 2006). The European Commission responded with an emergency regulation on Chinese food imports in 2008 and since April 2008, food products imported from China have to undergo testing to ensure that they are GM free (TIME, 2008).

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.

The following steps have to be completed by a company or GM technology inventor before a GM event can be imported into China: (Figure 1).

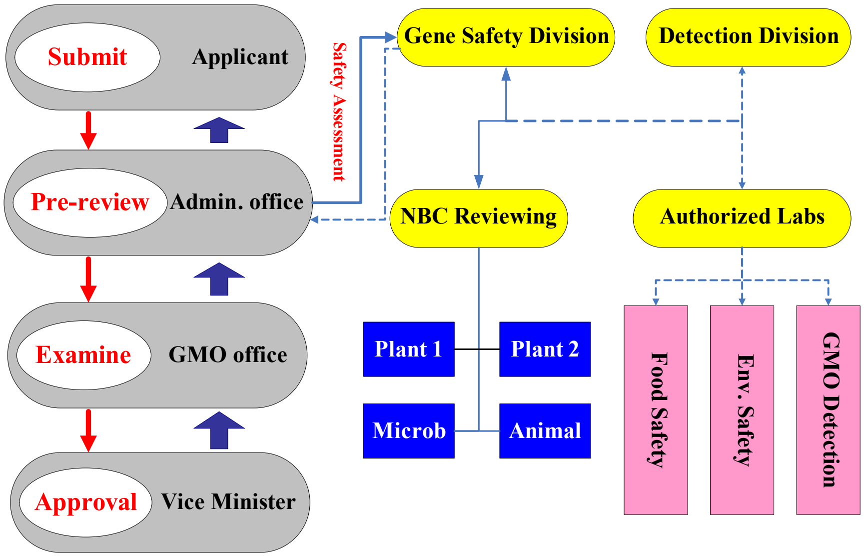
1. An application dossier to BMO for import permit of seed that contains the event. In addition to the required application documents, foreign institutions or companies must submit the related certificate of biosafety approvals from the country of origin.
2. The MOA's BMO evaluates the completeness of application materials.
3. After the application, MOA's BMO undertakes a biosafety evaluation and makes a recommendation on whether or not to allow the import of GM seed for food and feed safety trials and environmental safety trials. The evaluation is conducted by BC, which in the past was held twice a year and now three times a year.
4. Upon receipt of MOA's seed import permit, companies need to apply for a seed import license with the 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. The MOA's authorized agricultural biotech inspection institutions conduct biosafety trials. A typical food and feed safety trial consists of feeding the product to rats for 90 days. The environmental trial is conducted in the field during the crop growing season. For maize, environmental trials take about 110 days. The total cost is 310,000 yuan (about $48 thousand in 2010). Based on the results of biosafety trials, an authorized institution prepares a comprehensive biosafety trial report and submits it to MOA.
6. The report is evaluated by MOA's BC. As mentioned, there are three chances per year to submit

1 Among the 8 biotech plants, Bt cotton varieties originate from both domestic and foreign (Monsanto) technology providers, and all other 7 biotech plants were developed by Chinese scientists.

a biosafety trial report. If a report passes BC's evaluation, BC recommends to the MOA's BMO that it issue a GMO import permit for processing, food and feed uses. The BC can also request additional data or information, which can lead to delays in completing the application process.

7. A final decision to approve the import of a GM product is made by the MOA.

Figure 1. GM product import approval process in China.



The application process takes about 2 years. However, a delay in any of these seven steps could lead to delays of additional 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 trading 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, exporters from foreign countries should follow the following steps to export GM products to China, which normally take about a couple of months:

1. Exporters must submit an application to MOA's BMO for a GMO import permit.
2. After the application, MOA's BMO organizes biosafety evaluation and makes a recommendation on whether or not to allow importing the GMOs for processing of food or feed uses.
3. 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, the process for obtaining import permits is relatively simple. Requests for export or import permits have typically not taken 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 for testing. 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

Table 2: GM soybean events approved by USA, Brazil and China as of 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

samples need to be tested. The tests are done in a local laboratory that is contracted by 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 the testing procedure are discussed in Huang et al. (2008).

Based on China's biosafety regulations, MOA has approved three major GM events of soybeans (Table 2). Although there are many more soybean events that have been approved in major soybean producing countries, soybean exports to China from USA, Brazil and Argentina include these three approved events,[2] and there has not been any rejections of shipments over the past ten years, although this discrepancy in approvals could still pose a risk for traders exporting soybeans to China.

Greater concerns exist about LLP of GM maize in maize shipments destined for China. As shown in Table 3 (page 10) shows that the USA and Argentina, the two largest maize exporting countries in the world, have approved 29 and 11 GM events of maize, respectively. However, only 11 events of the 29 approved in the US have been approved in China. Although both China and Argentina approved a total of 11 GM events, some four events approved in Argentina have still not been approved in China (Table 3). Asynchronous authorizations of GM maize events has significant potential to undermine international trade, as has already been witnessed. For example, in November 2010, about 5.4 tons of GM maize imported from the United States were refused by China because a GM event, MON89034, that has not yet been approved in China was found in the shipment. Presently, the biotech industry is concerned about asynchronous authorizations of Agrisure Viptera™ (OECD Identifier: SYN-IR162-4), which has been approved in USA for commercial cultivation but is still undergoing the approval process in China in 2011.

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

Table 3. GM maize events approved by USA, Argentina and China as of 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

Worldwide, only a few GM events of rice have been approved. As shown in Table 4 (page 11), in 2011, there are 10 GM events available worldwide, but only 4 events have passed biosafety regulatory and no country claims that these GM rice events are already commercially available for food and feed uses, which reflects a more cautious attitude to cultivating GM rice, given that rice is the largest staple food crop in the world. Since China is a rice exporter, it should seriously consider pursuing approvals for its GM rice events from its major trade partners prior to commercial production, in order to avoid rice trade disruption resulting from LLP.

A summary of key trade-related biosafety regulation issues

The two major issues are asynchronous authorizations and the zero tolerance rule. According to China's biosafety regulation on GM imports, a Chinese approval process can only be launched after the foreign institution or company has gained biosafety approvals from the country of origin and submits these to the BMO. The entire approval process will then take at least 2-3 years to go through all 7

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

procedures and certain risk assessments. This results in considerable asynchronicity in authorization between exporting countries and China, creating a high likelihood of LLP and risk of trade disruptions.

The zero tolerance rule places further risks on GMO trade. Currently, China adopts a zero tolerance level for GM products not yet approved in China. This means that any imported product would be refused if events not yet authorized in China were detected. Combined with the asynchronous authorization of GM events between exporting countries and China, the zero tolerance will likely have significant trade implications.

Besides these two major issues, there are other three aspects that also generate additional costs to trade. These are the costs of the biosafety regulation, of testing of imports and personnel costs. Biosafety regulation and import testing cost are direct costs and can be easily measured, whereas costs related to personnel time spent on obtaining GM event authorizations and import permissions are not easily quantified.

3. Trade of GM rice, maize and soybean

We now provide an overview of China's trade of rice, maize and soybeans and assess the likelihood of LLP of biotech crops in both China's imports and exports. There are three commodities included in this 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 for 1996 to 2010. We focus on China's imports of soybean and maize and on its exports of rice.

To estimate the extent of GM products traded, the GM/non-GM commodities are classified according to whether the country of origin produces GM products or not. The commodities are defined as GM (or more accurately potential GM) if they are imported from GM producing countries, or as non-GM.

China's soybean imports are predominantly sourced from GM producing countries. As shown in Figure 2, the three top exporters of soybeans to China are USA, Brazil and Argentina. In 2010, China imported 54.8 million tons (or $25.1 billion) of soybeans, which was about 3.7 times larger than domestic production in the same year. The USA, Brazil and Argentina provided 43.1%, 33.9% and 20.4% of Chinese imports respectively, in 2010. Because the USA, Brazil and Argentina are the world's three largest GM soybean producing countries, based on the definition of GM and non-GM soybeans in this study, almost all the imported soybeans by China are GM products. As shown in Figure 3, imports of non-GM soybeans accounted for a very small share during 1996-2010. In 2010, GM soybean accounted for 97.4% of total imports, while non-GM soybean imports were only 2.6% of total China's soybean imports.

Figure 2. Chinese soybean imports , 1996-2010.

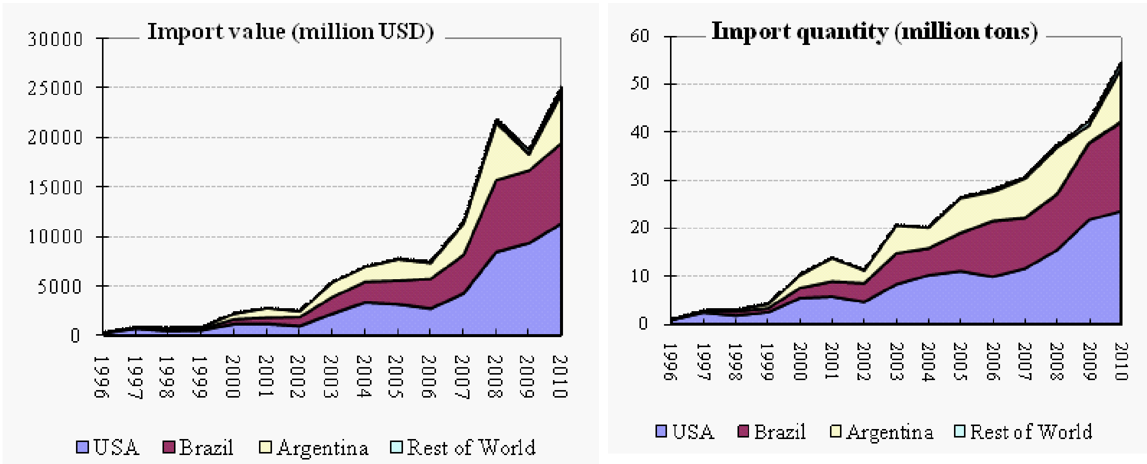
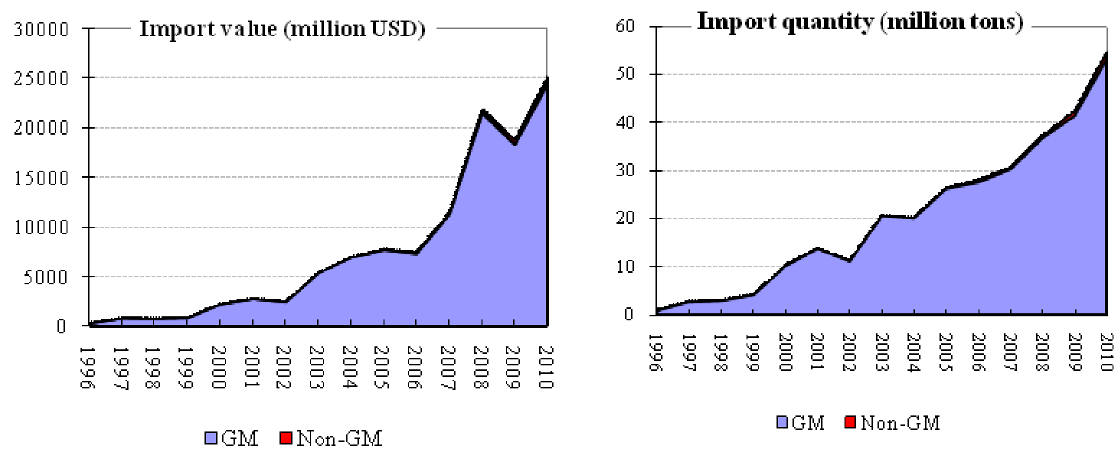
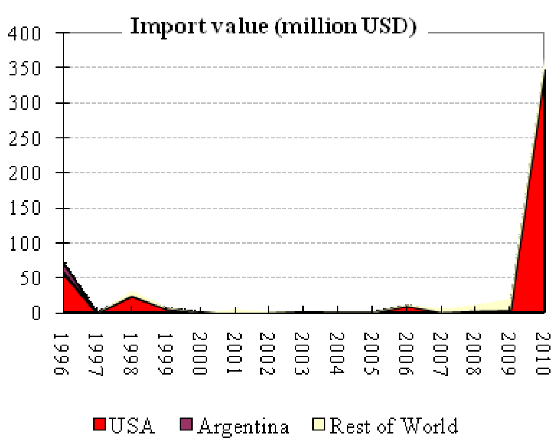


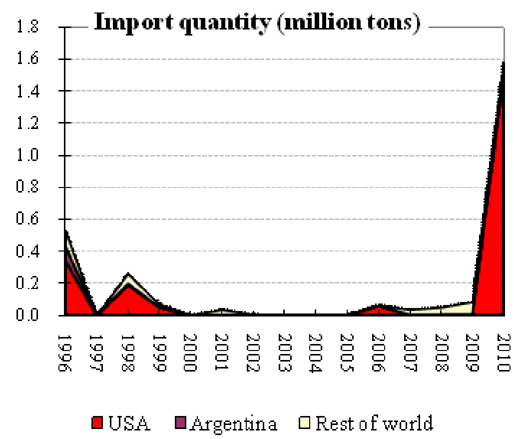
Figure 3. Chinese imports of GM and non-GM soybeans, 1996-2010





Similarly, China's imports of maize are dominated by GM varieties. China used to be a net exporter of maize from 2000-2009, with an annual average net export of 6.36 million tons (NSBC, 2010). However, Chinese maize exports have declined rapidly, especially in recent years because of fast rising domestic demand for maize for feed and processing uses. In 2010, China became a net importer, importing 1.57 million tons of maize (Figure 4). Based on recent projections, it is expected that

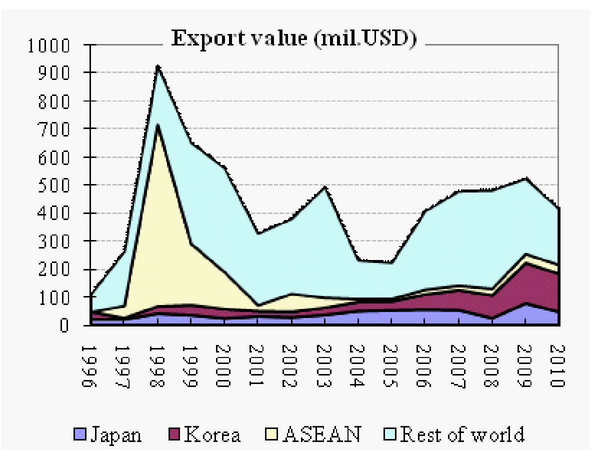
Figure 4. Chinese maize imports ,1996-2010

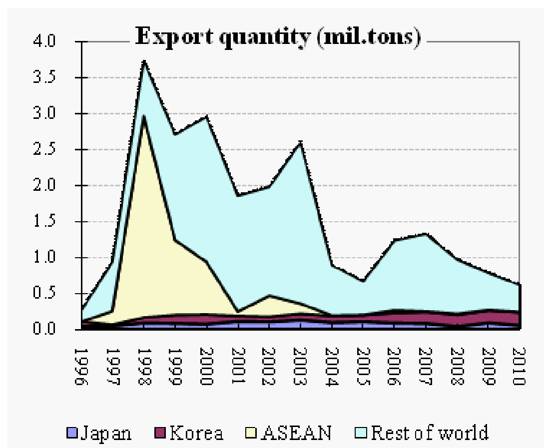


China's maize imports will continue to rise in the future (Huang et al., 2010). The USA, which is the world's largest GM maize producer, is the dominant maize exporter to China. As shown in Figure 4, China imported 1.5 million tons of maize from USA, accounting for 95.5% percent of total imports in 2010.[3]

Chinese rice exports have been declining, and exports only account for about 1 percent of domestic production. As shown in Figure 5, while the export values fluctuate during 1996-2010, there is an overall decline after 1998. Rice exports have dropped from 3.74 million in 1998 to 0.62 million tons in 2010 (Figure 5). Meanwhile, export share of total production has also been declining from a historical peak of 2.7% in 1998 to only 0.4% in 2010. However, Chinese exports of processed rice products, mainly rice flour and noodles (HS190230), have been increasing over time. According to the United Nations Commodity Trade Statistics database (UNCOMTRADE), exports of processed rice products reached 0.37 million tons, nearly 60% of milled rice export. The export value of rice flour and noodles is about $429 million US dollar in 2010, almost the same as total milled rice export value.

Figure 5: Chinese rice exports, 1996-2010





It is noteworthy that Japan and South Korea were significant export markets for Chinese rice in recent years (Figure 5). For example, the export of rice to Japan and Korean accounted for 44.0% in value terms and 37.0% in volume terms of China's total rice exports in 2010. As consumers in Japan and South Korea have been known to hold adverse opinions about GM products (Magnusson & Hursti, 2002; McCliskey & Wahl, 2003), if China does not seek 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 import bans in the future.

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

4. Methodology and scenarios

To understand the likely trade and economic implications of asynchronous authorizations of agricultural biotechnology varieties and resulting LLP, we employ the Global Trade Analysis Program (GTAP). 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 of and demands for 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 soybeans are part of a broader oilseeds category. Therefore, we split the key commodities (i.e., maize and soybeans) 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 GTAP database dates from 2004, we adopt the recursive dynamic method to update the GTAP data from 2004 to 2010 and project it to 2015. During the updating process, the growth rates of GDP, population, capital and labors in different regions are given exogenously. The information is calculated based on a database from the World Development Index (WDI) developed by the World Bank, International Monetary Fund (IMF) and the International Labour Organization (ILO). Such a method has previously been used in similar research (Walmsley et.al 2000; Meijl et al. 2002; van Tongeren et al. 2004). Meanwhile, trade liberalizations, especially related to China, are also taken into account. For example, Chinese tariff reductions pursuant to its WTO accession commitments, the elimination of the Multi-Fiber Arrangement (MFA), and the Free Trade Agreement (FTA) between China and the ASEAN countries as well as other FTAs are accounted for.

This case study employs four scenarios to simulate the impacts on production, trade and price of key commodities in China and its main trading 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 that there is no effect of LLP on trade and that global trade continues as usual. For the import scenarios of GM maize and soybean, we did not attempt to estimate the probability of imported GM maize or soybean being refused at China's border due to LLP of GM maize and soybean varieties not yet authorized in China. Instead, we chose to formulate two alternative scenarios, one with a lower range of refused import shipments and the other with a higher range of refused import shipments, in order to see the range of likely impacts. The assumptions of these three policy scenarios are briefly discussed below.

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 refusal rate for LLP			
M-10%:		-10%	
S-5%:			-5%
Higher refusal rate for LLP			
M-50%:		-50%	
S-10%:			-10%

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 gaining approval for the GM event in its major rice trading partners, it is very likely that China's rice exports could be banned. This scenario tries to capture the impacts of such a ban by all of China's trading partners on its agricultural production.

2. A lower refusal rate resulting from LLP of GM maize and soybean not yet authorized in China being exported to China. Under this scenario, GM maize and soybean imports to China would be reduced by 10% and 5%, respectively, relative to the reference scenario in 2015:
   - Reducing maize import by 10% (M-10%).
   - Reducing soybean import by 5% (S-5%).

3. We assume a relatively higher refusal rate for maize imports (10%) than soybeans (5%) for several reasons. Normally, there are relatively fewer GM soybean events than GM maize events. China has been a large importer of GM soybeans, and there has not been a single incident of an import refusal arising from LLP in a soybean shipment. For maize, however, LLP of GM maize not yet authorized in China did lead to import refusal in 2010 and is likely to reoccur in the coming years as we discussed in the previous section.

4. A higher refusal rates of LLP for GM maize and soybean not yet authorized in China exported to China. Here, we also assume two different refusal rates for soybean and maize. The import of maize and soybeans 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 50% (M-50%).
   - Reducing soybean import by 10% (S-10%).

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

Calculating the likely trade and economic implications of asynchronous authorizations of agricultural biotechnology and LLP is a complicated task. The impacts could be felt in both the short the long term. Some short term impacts are not easy to quantify. For example, when sizeable imports of GM commodities are rejected at the border of an importing country, the domestic market might not be able to respond by increasing supply (e.g., production and storage) in the short run, and the impacts in this case would be much larger than the results presented in this section since this study only includes the estimated impacts assuming that markets can effectively respond to an import shock. For this reason, we should consider that the results for each scenario simulated in this study likely underestimate the true costs. Some other impacts are also not incorporated in this study, such as the costs arising from trade disruptions and problems due to perceived risk of shipping GM maize and soybean to China, costs to exporters when GM maize and soybean have to be shipped back the original country or transferred to a third county.[4]

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

Table 6. Impacts of a ban on China's rice exports on production, price and trade of China's agricultural commodities, 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

With these caveats, the rest of this section presents the results that reflect the long term trade impacts of LLP of GM rice in Chinese exports, and GM maize and soybeans not yet authorized in China in its imports under three scenarios.

Ban on China's rice export

Simulation results show that a ban on Chinese GM rice exports is not likely to have large impacts on China's rice sector, nor on its wider economy. As shown in Table 6, when other countries ban China's GM rice exports, the domestic price and production drops by -0.32% and -0.45% respectively, relative to the reference scenario in 2015. A lower domestic rice price will also lead to a decline in rice imports (-2.79%). This result is easily understood considering the very small ratio (less than 1% in 2015) of rice exports to total rice production in China. Although the total effect is small, it is worth noting the effects of relocation of production resources. Because the production resources (labor, capital and land) will shift to other sectors besides rice, the price of other sectors will drop a little bit and their production will rise relative to the reference scenario (Table 6). Meanwhile their exports will increase and imports will decline as a result of rising competitiveness (i.e., lower price). As a whole, the social economic welfare in China will drop by about $4.0 million compared to the reference scenario in 2015.

Lower and higher refusal rates of importing maize and soybean

As shown in Table 7, if maize imports are reduced by 10% relative to the reference scenario, the domestic price of maize rises by 0.26% and the domestic production increases 0.62%. This slight increase of Chinese maize production will however occur at the expense of other agricultural sectors. The rising production of maize requires more inputs and competes with other sectors for production resources. Consequently, the prices of other sectors will increase due to rising production costs and

Table 7. Impacts of M-10% and M-50% scenarios on production, price and trade of China's agricultural commodities under, 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

their production will drop correspondingly (columns 2 and 3, Table 7). The import of other agricultural commodities will also increase as these become less competitive (column 1, Table 7).

There are much larger impacts if maize imports are 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 more significantly, with rising dependence on world markets 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, countries producing the GM maize not yet approved in China will assume the costs of export reductions. As shown in Table 8, US maize exports will drop by 0.59% and 3.0%, respectively, under the M-10% and M-50% scenarios. Reduced global market opportunity will also cause production to shrink. US maize production 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 other agricultural sectors. Although such an effect may offset the negative impacts of the LLP issue, the US maize sector will undoubtedly be hurt, especially under the higher refusal rate scenario.

Table 8. Impacts of M-10% and M-50% scenarios on production and trade of US agricultural commodities, 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 of S-5% and S-10% scenarios on production, price and trade of China's agricultural commodities , 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

The impacts of LLP on China's soybean production and price are considerable, even under the scenario of lower import refusal rates. As shown in Table 9, the soybean price and production in China will rise by 7.87 and 16.46% if the import of GM soybean is reduced by 5%. It will increase further under the situation of higher refusal rates. The soybean price and production will rise by 18.01 and 37.03% if imports of GM soybeans are reduced by 10% (column 5 and 6 of table 9). The much higher impacts on soybean prices and production stems from the larger import volume. According to the results of the reference scenario, China's soybean imports will continue increasing and will reach about 65 million tons by 2015. Moreover, the domestic production of soybeans is much smaller relative to imports. It accounted for about 17 million tons in 2015, just 26% (one quarter) of imports. Therefore, even with quite a small reduction of imports, there will be significant impacts on the domestic soybean market and price.

The increase in soybean production also occurs at the expense of other crops and livestock sectors. Their prices will increase, and conversely, their production 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 in the scenarios of S-5% and S-10%, compared to the reference scenario in 2015.

Similarly, the countries producing GM soybeans not yet approved in China will be confronted with reduced exports and production. As shown in Table 10, soybean exports from the three dominant exporters, the USA, Brazil and Argentina, will drop 1.75%, 1.80% and 3.37%, respectively, under the scenario S-5% in 2015. Furthermore, the decline in exports will be much more severe (3.57%, 3.65% and 6.78%, respectively) under the scenario of S-10%. Because of shrinking exports, the domestic production of soybeans will also decline significantly in these three countries. The production of soybeans 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).

Table 10. Impacts of S-5% and S-10% scenarios on trade and production of USA, Brazil and Argentina agricultural commodities , 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

6. Conclusions

China has developed its own strong biotech program and corresponding biosafety regulations for GM commercial production and import. The country considers GM technology as an important technology to increase its agricultural productivity and help meet its rapidly growing demand for food, feed and fiber.

While China has been developing its own biotech events for use in domestic production, it has not started to seek approval of its GM events in any foreign country. This may be explained by the fact that China's biotech program is aimed at improving domestic agricultural productivity and national food security. Since Chinese rice exports have been declining, the expected impacts of LLP of not yet authorized GM rice in the rest of world will be minimal. However, it is also worth noting that this study does not simulate the impacts of a possible ban on China's rice processed products. Giving the rising levels of exports of processed rice products from China, one would expect more significant trade and economic implications of a ban on China's GM rice exports in the future.

Moreover, as China continues to expand its biotech crop commercialization, even if the impacts on China's agricultural trade might be not significant, trade conflicts between China and its export markets could rise over time. Therefore, if China wants to minimize the risk of disruption of exports due to LLP and also contribute to a good external environment for the development of GM technology, China may consider seeking approval of its GM events in its major export destination countries in the future.

China's biosafety regulations on biotech crop imports require that import applications can only be launched after approval has been granted in the country of origin and set forth a zero tolerance rule, which will have important implications for maize and soybean production in USA, Brazil and Argentina and for their exports to China. Considering the huge and rising market opportunities in China for soybeans and maize, it is crucial that countries that are exporting or could potentially export large quantities of these two commodities to China pay attention to China's regulations on GM product imports. The trade and economic implications of asynchronous authorizations of agricultural biotechnology and LLP are likely to be significant. The disruption of trade in maize and soybeans caused by LLP will generate negative impacts on the production, prices and trade of China's main trading partners.

Meanwhile, the Chinese government should also consider the negative effects on its agriculture, food price and economic welfare arising from asynchronous approvals and LLP. One way to mitigate the negative effects of LLP would be for China to reduce regulatory asynchronicity. China could consider, for example, beginning its own import approval process for a biotech event before that event receives full approval in the country of origin.

Although in theory, the present zero tolerance rule prevents biosafety risks potentially resulting from imports of GM events not yet authorized in China, the costs implied can be significant and a cost-benefit analysis may be well advised. Based on the results of this study, a less trade distorting regulation on LLP can facilitate comparative advantage of agricultural production, stabilize domestic food price, and increase total social welfare.

There might be a win-win scenario by finding pragmatic policy solutions that seek to ensure the food and environmental 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 as proposed in the Codex Annex should be set up to enhance the safety management and also lower the multiple and often unnecessary costs of LLP.

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