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Will the Biosafety Protocol hinder or protect the developing world: Learning from China's experience

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Abstract

Uncertainties about the effect of Biosafety Protocol (BSP) on global agricultural trade have caused concern among those with a stake in agrifood imports and exports. The primary goal of this paper is to analyze the potential economic impacts of the BSP on both importing countries with a specific emphasis on China and exporting countries of soybean and maize. The results show that in absolute terms the BSP will require large investments internationally and will induce compliance costs. The BSP will increase the international price and domestic production in importing countries, and lower international trade and domestic production in the exporting countries. In absolute terms the impacts are large, amounting for each commodity into the tens of millions of dollars and varying largely among different scenarios. But in the percentage the impacts are small. Much smaller impacts are found in China because China has already invested in a system that provides almost all of the services that could be required by the BSP. Other developing nations may need more help; and that it will be more costly.

Keywords: LMO; Biosafety Protocol; Trade; Impact; China

Introduction

The Biosafety Protocol (BSP), a new international agreement that grew out of the Convention of Biological Diversity (CBD), entered into force in 2003. The main objective of the BSP is to contribute to the safe transfer across countries of living modified organisms (LMOs), which could be released into the environment and could affect the conservation and sustainability of biological diversity.[1] The BSP includes guidelines on how countries exporting LMOs need to document their presence and get a green light from importing countries through the use of "Advanced Informed Agreements." However, some of the proposed BSP provisions still lack details on how they are to be implemented in practice.

As countries continue to consider appropriate ways to implement the BSP's documentation requirements for shipments of LMOs, many questions remain about its potential economic impacts., The debate on such potential impacts has been particularly spirited in the case of LMOs intended for food, feed and processing (LMOs-FFP). Since most agricultural commodities around the world are produced and traded for food, feed and processing, biosafety labels for LMOs-FFP could prove costly and disruptive for world agricultural commodity trade (Kalaitzandonakes, 2004).

Uncertainties about the effect of the BSP on global agricultural trade have caused concern among those with a stake in agrifood imports and exports. The concerns about

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[1] The term "living modified organisms" or LMOs is therefore similar to the term "genetically modified organisms" or GMOs. The major difference between LMOs and GMOs is that LMOs are capable of reproducing whereas GMOs may not if already processed.

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the economic impacts of the different ways to implement the BSP documentation requirements are rising from a number of countries, regardless whether they have or have not ratified BSP, and are particularly pertinent for developing countries that are large importers of agricultural commodities. Answers to the likely impacts of implementing the BSP are important not only for large countries that have the capacity to develop biotechnology products of their own, but also for smaller nations that do not have the capacity to develop either biotechnology products or effective biosafety regulatory systems.

Recently, in response to the demand for answers to these questions, research has begun on the costs associated with the implementation of the BSP. An International Food and Agricultural Trade Policy Council (IPC) technical brief authored by Kalaitzandonakes (2004) documented in a detailed way some of the potential costs and benefits of the BSP. The report—which is based mostly on empirical work in the US, a major exporter—shows that compliance costs could be significant and distributed across the global food system. The report also proposes that a majority of the costs would likely be born by importing countries. However, the conclusions of the global impacts of BSP as well as its impacts on exporting countries from Kalaitzandonakes' study are based on qualitative conjecture. Indeed until now, there has not been any quantitative analysis of the various costs and benefits from implementing the BSP in importing countries and, more broadly, of its impacts on global agricultural commodity trade.

The primary goal of this study is to analyze the potential economic effects of alternative documentation requirements of the BSP for LMO-FFP shipments on both importing countries and exporting countries. We use China's experience in setting up and implementing a national biosafety regulation as a basis for our analysis. Our emphasis on China is, in part, motivated by the fact that over the last 15 years this country has developed its own biosafety regulation and monitoring system that includes many of the BSP labeling provisions providing real-world experience and data for our analysis. To limit the scope of our study, we restrict our analysis to two commodities: soybeans and maize. While not completely comprehensive, focusing on these two commodities is defensible because soybeans and maize account for more than 80% of global GM crop area (James, 2006) and a dominant share of all traded crops across the globe (Kalaitzandonakes, 2004). Moreover, the two crops are important commodities in China's agricultural trade basket. China imported more than 24 million metric tons of soybeans in 2005, most of them were genetically modified. China's soybean import activity also is important for world markets since China's share constitutes a large part of the world's traded soybean volume. In the case of maize China, at least in the short run, may be both an importer and exporter of maize. Such a set of dynamics provide some instructive contrasts in our analysis.

We also note that the economic impacts examined in this paper account for only certain dimensions of the potential compliance costs—the upfront costs associated with the establishment of a biosafety regulatory infrastructure; the operating costs of running it; the marginal costs of enforcing the BSP documentation disciplines for the shipment of biotech crops used in food, feed and processing. Other potential compliance costs include those associated with the implementation of the BSP disciplines in transboundary movements of research material and LMOs intended for release in the environment; and provisions on liability and redress.

To meet our goal, in the next section we briefly describe the evolution of the Biosafety Protocol and identify key issues related to the implementation of the BSP and its potential effects on trade. In the section "China's biosafety regulation", we review China's biosafety regulation and its overlap with the provisions of the BSP LMOs-FFP labeling requirements. In the section "The costs of testing LMOs: approach and baseline results", using figures from China's experience, we estimate the costs that the BSP will add to the *direct cost* of soybeans and maize as they travel across the globe under alternative documentation regimes. In the section "The impact analysis of BSP on China and the rest of the world using GTAP", we simulate the *fuller impacts* of the BSP on commodity prices, production, consumption and trade. Finally, in the section "The full impacts of the BSP" we conclude and draw conclusions on the potential impacts of the BSP on the world and on China.

The evolution of the Biosafety Protocol and key issues related to trade

The BSP emerged from the CBD which itself contains specific provisions on certain biotechnology products but also emphasized the need for a protocol to set out conditions for their safe transfer, handling and use (Mackenzie, 2003). In 1994, at the first CBD conference the parties to the convention authorized a series of meetings to consider the "need and modalities" for such a protocol. A draft of the Protocol was produced in February 1999 at a meeting held in Cartagena, Colombia and was adapted on January 29, 2000 in Montreal, Canada. On September 11, 2003, the BSP entered into force and as of November 2006, 136 countries had ratified it.

The BSP's stated objective is to contribute to the safe transfer, handling and use of all LMOs that could adversely affect the conservation and sustainability of biological diversity or pose risks to human health. The BSP defines LMOs as those living organisms (e.g. plants, trees and animals including fish) with novel genetic material introduced through the use of modern biotechnology (i.e. recombinant DNA and cell fusion techniques). Two types of LMO uses are the main focus of the BSP: intentional release to the environment; and the direct use for food, feed and processing. To ensure the safe transfer, handling and use of LMOs the Protocol includes several broad and cross-cutting provisions.

For the safe transfer and handling of LMOs intended for introduction to the environment, the BSP requires the use of Advanced Informed Agreements (AIAs). Prior to the first transboundary transfer exporters must provide documentation with detailed information about the LMO and its intended use. The importing country then can evaluate the information and perform risk analysis in order to decide whether to allow importation of the LMO or request additional information in accordance with its domestic regulatory framework.

Importing countries can place conditions or refuse imports when they judge that there is insufficient knowledge regarding the potential impact of specific LMOs on their biodiversity. Indeed, the BSP, in-line with the CBD, has advocated the use of the "precautionary principle" (deGreef, 2004). In this context, the BSP allows restrictions on the trade of LMOs in the presence of perceived risks, however small. The BSP also allows importers to take into account the socioeconomic impacts that could emerge from the importation of the LMOs.

Transboundary shipments of LMOs-FFP do not require AIAs. Instead, countries must report biosafety regulatory decisions that permit the cultivation of LMOs inside their borders through a web-based database—the Biosafety Clearinghouse. Furthermore, exporting countries must provide relevant information about cargoes containing LMOs-FFP and indicate that they are not intended for introduction in the environment. Importing countries could require prior consent for the importation of LMOs-FFP in a way consistent with domestic regulatory policies by indicating so in the Biosafety Clearinghouse. Countries that lack regulatory infrastructure might still reserve the right to an evaluation on the first importation of an LMO-FFP and, as with AIAs, they can use "precaution" and socioeconomic considerations in reaching their decision.

A variety of other provisions also are included in the BSP such as: simplified procedures for the transboundary movement of LMOs that present minimal risk; emergency measures for unintentional or illegal transboundary movements of LMOs; as well as rules and procedures for liability and redress in the case of damages caused by LMOs. Because of its broad rules and comprehensive procedures, the BSP has been viewed by some as a first step to a homogeneous and harmonious global biosafety regulatory framework (Jaffe, 2005).

Despite the potential for greater safety and integration, there are real concerns about the ultimate effect of the BSP. Some have cautioned that because of the limited definition of key provisions, the BSP may fall short of delivering on its key objective: the establishment of a harmonious regulatory system with standardized rules which safeguards the environment and effectuates international trade (Jaffe, 2005). Others have gone further suggesting that the differential capacity of various countries to implement the BSP could, in fact, impede technology transfer and agricultural trade (Watanabe et al., 2004). Beyond technical concerns, others have also noted that some of the BSP provisions themselves could lead to trade restrictions and significant compliance costs (Kalaitzandonakes, 2006). Indeed, some of the BSP provisions still lack detail on how they are to be implemented in practice. Key among them are the specific requirements for the labeling of LMOs-FFP. Since most agricultural commodities around the world are produced and traded for food, feed and processing, biosafety labels for LMOs-FFP could prove costly and disruptive for world agricultural commodity trade. How costly and disruptive will, ultimately, be determined by the implementation details of the labeling scheme for LMOs-FFP which are still under consideration.

On these labeling requirements, the original text of article 18.2(A) of the BSP dictated that

> Each party shall take measures to require that documentation accompanying living modified organisms that are intended for direct use as food or feed, or for processing, clearly identifies that they "may contain" living modified organisms and are not intended for intentional introduction into the environment, as well as a contact point for further information. The Conference of the Parties, serving as the meeting of the Parties to this Protocol shall take a decision on the detail requirements for this purpose, including specification of their identity and any unique identification, no later than two years after the date of entry into force of this Protocol.

The "detailed requirements" called for in article 18.2 (A) can be grouped into three relevant sets. The first set would specify allowances for accidental commingling of small amounts of LMOs with conventional crops in export cargoes. Such "adventitious presence" thresholds would, in turn, determine what is an LMO and when labeling might be necessary. A second set would cover the specific content of the information that must be provided by exporters and how such information should be collected. The third set would detail how importers receive and, in turn, use the information provided by exporters.

Over the years, negotiations have focused on the second set of requirements—what to label and how? Far more than theoretical concerns, the process to make decisions on the implementation details of the BSP has been ongoing in the mid-2000s. The signatory parties were obligated by the BSP to decide on the "detailed labeling requirements" for LMOs-FFP within two years from its entry into force. Yet, by the end of the second meeting of the parties (MOP-2) in June 2005 no consensus could be reached. Positions on the exact content of the labels supported in the past by various stakeholders have included:

- Use a label which indicates that a cargo "may contain" LMOs and is not intended for planting;
- Use more a detailed label that explicitly states it "contains" LMOs and identifies the specific LMOs in the cargo;

- Use an even more detailed label that identifies the specific LMOs contained in the cargo and quantifies their shares/amounts.

Much of the debate in the MOP-3 meetings that took place in Brazil in March of 2006, centered on the first two options and in the end both were allowed, at least for the present time. In cases where the identity of the LMOs in a particular cargo is "known through means such as identity preservation systems" a label that identifies the LMOs contained in the cargo is required. When the identity of the LMOs is not known through such means, a "may contain" label must be used. In both instances, the common scientific name of the LMO and the transformation event or the unique identifier/code that connects the LMO to the BCH must be provided by the exporter. The Parties also agreed to "review and assess the experience gained with the implementation" of such labeling options during the MOP-5 in 2010 with "a view to considering a decision" in the MOP-6 in 2012 for requiring the stricter label which identifies the LMOs contained in all cargoes as the overall standard.

There are good reasons for the continuing hesitation and angst over the decision on how to label LMOs-FFP. Since crops change hands multiple times as they travel through the marketing chain, co-mingled time and again in storage and transport, the exporter is the last in a long series of entrepreneurs that take ownership of the crops along their journey from the farm field to the export harbor. Importantly, the exporter is also the holder of the largest cargo in the supply chain. Export vessels typically contain product from some forty barges or nearly 600 train cars which in turn could include crops from hundreds of farms. Hence, under current typical operations, exporters do not know the LMO content of their cargoes.

Certainly, in the absence of a deliberate effort to exclude LMOs from cargoes through strict segregation of crops from the field to the port, vessels originating from countries with meaningful LMO production should be expected to contain LMOs. The exact level of LMOs, however, will vary drastically across vessels depending on the production profile of the regions where the cargoes originated. Similarly, commercial production of an LMO in a country does not automatically warrant its presence in a particular export cargo. Accordingly, without testing each cargo for the presence of individual LMOs, exporters would be unable to indicate that cargos definitively "contain" specific LMOs simply on the basis that they are commercially produced in a given country. Under these conditions, the most accurate reporting by exporters might be to indicate that a cargo "may contain LMOs" while listing all those potentially present in the cargo. Such labeling can be implemented under today's conditions with modest operational changes and compliance costs.

Implementing "contain" labels when cargoes are known to contain specific LMOs through means of identity preservation also implies modest operational adjustments and costs. However, the possibility that the identity of the LMOs in an export cargo will be known through an identity preservation system is rather limited today. Only a very small share of international traded agricultural commodities is currently identity preserved and, in most cases, such systems ensure the absence of LMOs not their presence.[2] In contrast, generalizing the "contain" labels for all LMOs-FFP implies far greater complexity as it involves broad testing.

Clearly, many questions remain about the ways that the BSP might be implemented and its potential impacts. In this paper we seek answers to just such a set of questions by analyzing what will be required for countries to implement the basic provisions of the BSP and on the implications of alternative labeling regimes for LMOs-FFP on trade and economic welfare. We begin by examining China's experience in building a biosafety regulatory infrastructure in order to draw conclusions on the demands of designing and implementing the monitoring and labeling requirements of the BSP.

China's biosafety regulation

When evaluating the potential impacts of implementing the BSP, activities for both setting up and operating the necessary biosafety bureaucracy as well as ensuring compliance must be considered.[3] On both such sets of activities China has important advantages that are not shared by many other developing countries. Aided by its strong centralized governance, sound scientific/management infrastructure and large number of scientists, China has developed a comprehensive biosafety regulatory system in the course of the last 15 years (Huang et al., 2005).

As a result of increasing imports of LMOs-FFP and the commercialization of Bt cotton inside China, China has raised its annual budget for biosafety-related activities significantly over the past several years (Huang et al., 2005). By 2004, the annual operating expenditures for agricultural GMO biosafety research reached almost $2.5 million. Currently, China spends about US$ 3 million annually on agricultural biosafety related works (excluding the expenditures required to implement its

[2] See Kalaitzandonakes (2004) for details on the scope of identity preserved programs targeting non-GMO corn and soybean markets in Japan and in Europe.

[3] One of the important implications of this section—especially when analyzing the effect of the BSP protocol on trade in importing countries—is that countries, in addition to paying for the variables cost of testing, need also to make the fixed investment in the system itself. In the case of a small, infrequent importing country, it may be that this fixed cost is a large burden. In addition, if there are scale economies in testing, the costs of testing in smaller countries may be higher and so our analysis may need to be adjusted for smaller countries (and the impact could be higher).

labeling and market inspection duties inside China and at the border).

China's ministry of agriculture (MOA) is the primary organization in charge of the implementation of agricultural biosafety regulations and its biosafety regime functions relatively well with regards to monitoring and regulating the imports of LMOs. There are several reasons for this. First, China already has a well-established domestic regulatory system for many other parts of its food system. Second, China already had experience with the issues of importing GM soybeans. Finally, the new biosafety system was not created anew, but, rather, it was patterned after (and in many cases built up next to) the institutions that China has developed to regulate the food imports through a more traditional quarantine system.[4]

The depth of China's system can be seen by examining some of the procedures it has developed to deal with the trade of GMOs. For example, 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 LMOs, 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 the mid-2000s, requests for export or import permits have typically taken no more than 30 days to issue. 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 3–6 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 1000 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 LMOs or not and what types of LMOs are present. When comparing China's current biosafety regulation with the BSP labeling requirements for LMOs-FFP it becomes clear that China's procedures already exceed the current labeling regimes settled on during the March 2006 MOP-3.

Table 1
Chinas' soybean imports (1000 tons) by source country, 2001–2005

	2001	2002	2003	2004	2005(1–11)
USA	5726	4619	8293	10,198	9107
Brazil	3160	3910	6470	5616	7375
Argentina	5020	2775	5964	4403	7303
Canada	15	12	13	13	11
Others	15	0	0	1	181
Total	13,937	11,315	20,741	20,230	23,977

Note: The data are for the period of January–November in 2005.
Source: China's Custom Statistics.

GM soybean imports

The large and rising volume of imported GM soybean under China's biosafety regulatory regime provides a good empirical case to examine the costs of testing LMOs as well. Since the late 1990s, with the opening of the domestic soybean market to international trade, China's soybean imports have increased significantly. After 2003, annual soybean imports exceeded 20 million metric tons, accounting for more than 55% of domestic demand (Table 1). Because China primarily sources soybeans from GMO producing countries, most of the imported soybeans are LMOs. Between 2001 and 2005, more than 99% of China's soybeans came from the US, Brazil and Argentina. During each year, the share of imports from the US has been the largest, although the relative shares of the three sources fluctuate over time.

In addition, since GM soybean imports enter China through almost all of its ports, China has already had to invest into the biosafety import monitoring and management systems in many different locations.[5] Finally, because almost all imported soybeans are immediately delivered to crushing plants on or close to the port and turned into soybean oil and meal, there is a very limited chance that unauthorized LMOs could find their way to local production. All of these issues, of course, affect our assessment of the compliance cost associated with China's biosafety

[4] Although one is never sure as to the actual motive for establishing a new set of institutions (such as those needed for implementing the Biosafety Protocol), it is fairly clear that the investment to set up China's current system (which we claim is part of its food and quarantine system) is related to its desire to maintain a safe food system (and monitor incoming agricultural commodities) and, more specifically, to monitor incoming shipment of GMOs. China is concerned with tracking GMOs for several reasons—including being concerned that some of the products might get into the environment without being tested or that they may get into the food system when they have not been proven to be safe for human consumption.

[5] It was beyond the scope of this paper to estimate how much investment went into creating China's own biosafety management system, though certainly it was be considerable since there were major investments made into personnel, office facilities, laboratories, etc. Even if one tried to quantify the investment needed to set up the domestic biosafety program, it would be difficult. Many of the personnel and office facilities are shared with other custom agencies, making attributing costs difficult.

regulation but are instructive for other countries that plan to implement the Protocol.

The costs of testing LMOs: approach and baseline results

Collecting the data on testing costs for biosafety assessment in China

The first step in our analysis entailed collecting information on the direct costs that China's biosafety regulation imposes on exporters and importers of soybeans and maize. The data collection effort included eliciting information on (a) the number and size of the vessels that bring soybeans and maize to China; (b) the cost of testing for different types of ships; and (c) an assessment of other, non-testing costs. The enumeration team collected detail trade records on soybean and visited with the port authorities in six major coastal cities, officials in charge of China's biosafety regulation, officials in charge of traditional quarantine inspection and personnel in the laboratories that conduct the testing for LMOs. Members of the team also visited soybean traders and importers to cross-check the information given to them by the government officials.

From our survey we were able to estimate the total number of vessels and sizes of the vessels that arrived China with imported soybean in 2005 (Table 2). According to our data, all but six of the shipments arrived in large, panamax-type vessels that averaged around 60,000 tons. In addition, 25% of soybean vessels contained more than 60,000 tons; only six vessels were about 5000 tons. Arriving from Brazil and Argentina in the summer and from the US in the winter months, China's ports hosted more than one vessel per day.

For a cargo of 60,000 tons, China's biosafety inspectors take an average of 70 samples (20 for the first 10,000 tons; 50 for the rest 50,000 tons or 1 for each of the next 1000 tons). In total, in 2005 testing laboratories tested 29,040 samples of LMOs from the 420 vessels (Table 2). On average, a sample was taken for each 840 tons that arrived in China's ports in 2005 (a piece of information that is used in our analysis to calculate the average per ton cost of testing).

During our visits to the testing laboratories we also asked a series of questions about the cost of testing the samples under current and alternative testing criteria (Table 3, column 2).[6] The respondents in the laboratory told us that the current cost of testing soybeans is 2900 yuan per sample (or US$358—row 1). The costs included both the laboratory testing costs (about 70% of the value) and other service charges assessed by the port (about 30%) on a per sample basis. Since each sample on average was 840 tons, this means that in 2005 importers paid US$0.43 per ton (358/840—row 2) or US$10.4 million (row 3). Given the average CIF price of soybeans in 2005 was US$282, this means that, on average, biosafety testing cost was about 0.15% of the price of soybeans (rows 4 and 5).

We also priced the potential testing costs of two alternative documentation regimes that have been broadly discussed and considered in the context of the BSP

Table 2
Estimating the number of test samples for soybeans in China in 2005

	Number of vessels	Samples per vessel	Estimated number of samples
About 5000 tons/vessel	6	10	60
About 60,000 tons/vessel	414	70	28,980
Total	420		29,040

Note: Average sample is 840 tons based on China's regulation.
Source: Authors' survey.

Table 3
Estimated total costs for laboratory and other related costs for LMOs at the border in China in 2005

	"Contains LMOs"	"Identifies LMOs" (current case)	"Quantifies LMOs"
Soybean (import)			
Cost per sample (US$)	286	358	481
Cost per ton (US$)	0.34	0.43	0.57
Total cost (million US$)	8.32	10.40	13.98
CIF in January 2006 (US$/ton)	282	282	282
Share of CIF price (%)	0.12	0.15	0.20
Maize			
Cost per sample (US$)	286	716	1332
Cost per ton (US$)	0.34	0.85	1.59
For import:			
CIF in January 2006 (US$/ton)	140	140	140
Share of CIF price (%)	0.24	0.61	1.13
Total cost (million US$)	0	0	0
For export:			
FOB in January 2006 (US$/ton)	135	135	135
Share of FOB price (%)	0.25	0.63	1.17
Total cost (million US$)	0	0	0

Note: Costs include laboratory testing costs (about 70%) and other service charges (about 30%) to importers if the Biosafety Protocol would be applied in 2005. China did not import maize and did not export GM maize in 2005, so the total estimated costs associated with the Biosafety Protocol were zero.
Source: Authors' survey.

[6] It should be noted that we are using information on testing for 2005 (from our survey) to project costs for 2010. While there should be no problem in the assumption that the unit costs are the same (there is no reason to expect China to dramatically raise the cost of a test), there is less certainty about the compliment of GM events that will have to be tested for five years in the future. In other words, in our analysis we assume that, as is the current case, there is only one soybean event and seven maize events that are being tested for. It is certainly possible that over the coming years the number of GM events for both soybeans and maize increase and become more complicated (since there may be more stacked events, etc.). Since it is difficult to predict this, we have little alternative to the current assumption. But, it should be noted, that actually testing costs may increase because of this.

negotiations (Table 3, columns 1 and 3). When testing soybeans under the least strict criteria which simply verifies the existence or absence of LMOs but does not identifies which ones (henceforth, simply "contains LMOs"), the cost per sample was US$286, about 20% lower. We also evaluated the costs associated with a stricter labeling and documentation regime which requires the lab to quantify the *shares* of each type of each LMO in the vessel (henceforth, simply "quantifies LMOs").[7] Under this regime, the cost per sample rises to US$481 per ton. The total cost reaches US$ 13.98 millions and the per ton cost is US$ 0.57 or about 0.2% of the CIF price. Because there are several different types of GM maize events commercialized, (there are seven approved for import into China; plus there are a number of stacked events, which are not yet approved for import into China), testing to identify the type of LMO (Table 3, column 2) and to quantify the share (column 3) is more expensive. Only under the "contains" labeling regime testing costs remain the same.

We make one additional assumption about the testing procedures. While we have not accounted for time delays given the ability of China's lab infrastructure to deal with the current load, the possibility for such delays (and significant incremental costs in the form of demurrage charges) exists, especially in other developing countries where the testing/laboratory infrastructure is limited or non-existent.

Testing costs in the US

Since we are going to simulate the potential economic impacts of the alternative BSP documentation requirements globally, we need testing costs for maize and soybeans in the rest of the world (we report our estimates of the testing costs of the US—Table 4).[8] To do so we follow the methodology used in Kalaitzandonakes (2004). When testing soybeans in the US under the least strict criteria "contains LMOs" and "identifies LMOs" test is used at a laboratory cost of $180 per sample.[9] Along with a 20% in port service charges, the cost for this test is $216 per sample. When using the more strict criteria a quantitative test for the same event is performed at the cost of $324 per sample. An estimated 965 vessels averaging 29,210 metric tons cargo is assumed to be subjected to a similar testing regime as that used in China. Accordingly, on average, 40 samples are assumed to be collected and tested from each soybean export vessel from the US with an average tonnage of 730 metric tons per sample and an estimated total cost of US$8.3 to US$12.5 million. On a per ton basis, testing costs for soybean exports from the US vary between 0.12 and 0.18% of the FOB price.

Testing costs for US maize exports, however, are more expensive. With eight commercial events in production, the costs of the three testing regimes are different. Under the least strict criteria "contains LMOs" test is sufficient implying laboratory costs of $380 per sample. Along with the 20% service charges, the testing expenditure is equal to $456 per sample. The more demanding regime that "identifies LMOs" requires a quantitative test at the cost of $1280/sample. After the charges, the per sample costs for the most restrictive regime is $1536. The overall testing costs for maize exported from the US range from $34 to $115 million. As a share of the FOB maize price, testing costs represent 0.64–2.15%—certainly significantly higher than in the case of China. With these adjustments, the final testing costs that are applied to LMO soybeans and maize as a share of FOB and CIF prices (depending on whether the country was an exporter or importer) are reported in Table 5.

Table 4
Estimated LMO testing costs of and other fees associated with exporting soybean and maize from the USA

	"Contains LMOs"	"Identifies LMOs"	"Quantifies LMOs"
Soybeans			
Cost per sample (US$)	216	216	324
Cost per ton (US$)	0.30	0.30	0.44
FOB per ton in January 2006 (US$)	245	245	245
Share of FOB price (%)	0.12	0.18	0.18
Total cost (million US$)	8.33	8.33	12.5
Maize			
Cost per sample (US$)	456	792	1536
Cost per ton (US$)	0.67	1.16	2.26
FOB per ton in January 2006 (US$)	105	105	105
Share of FOB price (%)	0.64	1.14	2.15
Total cost (million US$)	34.2	59.3	115.1

Note: Costs include laboratory testing costs (about 80%) and other service charges (about 20%).
Source: Authors' calculations.

Table 5
Assumed costs of testing and other fees under alternative scenarios

	"Contains LMOs"—I	"Identifies LMOs"—II	"Quantifies LMOs"—III
LMO soybean			
Share of FOB price (%)	0.12	0.18	0.18
Share of CIF price (%)	0.12	0.15	0.20
LMO maize			
Share of FOB price (%)	0.64	1.14	2.15
Share of CIF price (%)	0.24	0.61	1.13

Note: All LMO exporting countries use the USA's costs; all LMO importing countries use the China's costs.

[7] This option was discussed in the MOP-2 but not in the MOP-3 and it appears to have lost support. However, it is unclear whether it could resurface as an option in future negotiations during the review of the "may contain" label. Here it is presented for comparison purposes.

[8] Another assumption of our study is that the testing costs in all countries of the world are similar to those in China and North America. Since we do not have any information on the testing costs associated with the BSP, we can only assume that the costs of importing nations are similar to those of China and those of exporting countries are similar to those of the US, Brazil and Argentina.

[9] In the case of soybeans with just one commercial trait (roundup ready) in the market, the tests for "contains LMOs" and "identifies LMOs" used in the US are the same and imply the same costs.

The impact analysis of BSP on China and the rest of the world using GTAP

The impacts of implementing the BSP worldwide (and on China) are analyzed under the three alternative labeling regimes and simulated using the modeling framework developed by the Global Trade Analysis Project (GTAP). GTAP is a multi-region, multi-sector computable general equilibrium model. The model approach is fully described in Hertel (1997). It has been used to generate projections of policy shifts and biotechnology breakthroughs in China in the future (Arndt et al., 1997; Huang et al., 2004a,b).

In our GTAP approach, taxes and other policy measures are represented as ad valorem tax equivalents. These create wedges between the undistorted prices (e.g., the price before the implementation of the BSP) and the policy-inclusive prices (the price after the implementation of the BSP). Production taxes are placed on intermediate or primary inputs, or on output. Trade policy instruments include applied most-favored nation tariffs, antidumping duties, countervailing duties, export quotas and other trade restrictions. Additional internal taxes can be placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Taxes can also be placed on exports and on primary factor income. In this study we impose additional costs at the border for imports and exports of LMOs that are related to BSP implementation. In other words, because port authorities in exporting and importing countries require additional testing, the real price of exports will be higher as will the real price of imports.

Data adjustments and improvements

The GTAP database contains detailed bilateral trade, transport and protection data characterizing economic linkages among regions, linked together with individual country input–output databases which account for intersectoral linkages among the 57 sectors in each of the 87 regions. Unfortunately, soybeans and maize are not independent sectors. Because of this, we needed to modify the database to have separate commodity groups for both soybean and maize for all countries (see Appendix for detail). The base year for version 6 is 2001.

Before we apply GTAP version 6 for the current analysis of the impact of the BSP, we carefully examined the database and parameters for China and made a number of adjustments. These changes improved the database in several ways, especially in the agricultural input and output ratios, demand parameters, trade policies and production values. The main ways that we adjusted the database are listed in Appendix.

Scenarios and impacts

Because of the uncertainties in the detailed LMO-FFP labeling requirements that will ultimately be required by the BSP, the analysis runs the model to assess its potential impacts under alternative scenarios. We begin by running the baseline scenario—the equivalent of no testing for LMOs at the national border. This is also approximately equivalent to the minimum BSP documentation requirement where a "may contain" label would be used. Under such documentation requirement information on the country of origin of the commodity instead of testing would be sufficient to raise the possibility that LMOs may be present in the cargo and prompt the "may contain" label. Following Table 5, we run the model under three alternative scenarios: scenario I for the least strict criteria that requires traders to indicate that the cargoes "contain" LMOs; scenario II for the second criteria (which is also China's current criteria) requiring traders to "identify" the types of LMOs contained in the cargo; and scenario III for the most strict criteria that requires the traders to "quantify" the LMOs present in the shipment.

We then examine the impact of the BSP on different parameters of interest. The first and most direct is the impact of the BSP on prices. While this is primarily influenced by the nature of the cost of testing (the direct costs of testing required by the BSP), as prices rise from these compliance costs, consumers in the importing countries demand less and domestic producers supply more because they are facing higher, quasi-BSP-protected price. The price impacts in our analysis account for all direct and indirect effects of the BSP. Given the change in prices, we also examine the effect on international trade and domestic and world production. It is important to note that in our analysis the impact of the BSP is different in China since it already has implemented its own biosafety regulations. This is explained in the discussion of the results below.

The full impacts of the BSP

As expected, after the world implements the BSP in 2010 the international price of soybeans and maize will rise (Table 6). Regardless of what decision is made on the criteria for testing international shipments for LMOs, according to our analysis the international price of LMO soybeans will rise by 0.07–0.11% (columns 1–3, row 1). Reflecting both the fact that the cost of testing is relatively higher (on a per ton basis) and the more complicated nature of testing (since there are more individual and stacked GM events used), the international price of maize will rise proportionately more under all three scenarios, from 0.31% to 1.07% (columns 4–6, row 1).

Interestingly, because of the nature of the reactions of producers and consumers around the world in response to the extra cost of testing, the increase in the international price is less than the testing cost itself. For example, in the case of scenario I for soybeans, by 2010 the international price rises by 0.07% (Table 6, column 1, row 1). This rise in price, however, is less than the amount added in percentage terms by the cost of testing (0.12 on both a CIF and FOB basis—Table 5, column 1, rows 1 and 2). The reason

Table 6
Impacts (%) of Biosafety Protocol on international and domestic prices of soybeans and maize under alternative scenarios, 2010

	Soybean			Maize		
	I	II	III	I	II	III
International prices	0.07	0.10	0.11	0.31	0.56	1.07
Domestic prices						
China	0.06	0.08	0.10	0.09	0.17	0.33
NAFTA	−0.03	−0.05	−0.07	−0.05	−0.09	−0.17
South and Central America	−0.02	−0.03	−0.04	−0.04	−0.07	−0.13

for this, of course, can be seen in Table 7. When the CIF and FOB prices rise internationally due to the cost of testing required by the BSP, world trade in soybeans falls (columns 1–3, rows 1). At higher world prices, importers demand less soybeans, 12.1 million dollars less when using a "contain" label. When the strictest criterion is imposed, the fall in world trade is 18.7 million dollars. World trade for maize falls from between 20.2 and 74.7 million dollars due to the BSP (columns 4–6, row 1). Of course, when importers demand less, the international price falls, and so the final impact on world prices is less than the rise in price due to testing.

The analysis of the BSP impact on world trade volumes also shows the tension between trying to decide if the effect of the protocol is large or small. In absolute terms that amount of trade that is affected by 2010 is large and rises as the labeling and reporting requirements for LMOs-FFP become increasingly strict (Table 7, row 1). However, in terms of the impact on percent of world trade, the effect appears fairly small (Table 7, row 5). World soybean trade falls from between 0.08 and 0.12 of the baseline rate in 2010, which, even given the strictest criterion, is only a bit more than one-tenth of 1% of the total volume of trade. The volume of maize falls somewhat more, it falls by near 1% (0.87%) given the most strict criterion. The reason, of course, is that even though on an absolute basis the decline is large, the volume of world soybean and maize trade is enormous and the price effect of the BSP, while significant in absolute terms, is relatively small in percentage terms.

While the trade flows fall for all the countries (Table 7, rows 2–4; rows 6–8), the direction of the impact of the domestic price changes depends on whether a country is a net exporter (e.g., NAFTA countries or South and Central American countries) or importer (e.g., China). For instance, in the case of China the difference between implementing and not implementing its domestic biosafety regulations (which is equivalent to scenario II), means that China's domestic price of soybeans is higher by 0.08% and the domestic price of maize is higher by 1.12%. In contrast, the domestic prices of soybeans and maize fall in the NAFTA and South and Central American countries. In other words, the BSP acts similar to a tariff, keeping trade down and forcing prices up for importing countries and reducing domestic price in exporting nations.

It is interesting to note that if the BSP ultimately decides to require countries to test for the presence of LMOs in international shipments on the basis scenario I or II, there would be no effect on China. The measured upward pressure on prices and the downward impact on trade in scenarios I and II is probably already exceeded by the current situation in China which implemented its own domestic set of biosafety regulations. However, these numbers are still useful in discerning the variable costs (that is, net of initial investment costs) of biosafety in general. In other words, because China already has its own set of domestic regulations, the only impact of the BSP would come if the labeling requirements for LMOs-FFP demanded that importers quantify the shares of different LMOs within each vessel (that is criterion III). If this were the case, the effect on China's soybean price would only be 0.02% (0.10–0.08). The effect on China's maize price would be 0.16% (0.33–0.17). In other words, the marginal impact

Table 7
Impacts of Biosafety Protocol on international trade of soybeans and maize under alternative scenarios, 2010

	Soybean			Maize		
	I	II	III	I	II	III
In million US$						
World trade	−12.1	−16.4	−18.7	−20.2	−40.2	−74.7
China's import	−3.9	−5.4	−6.2	−6.1	−12.1	−22.5
NAFTA's export	−7.8	−10.2	−10.7	−21.7	−43.4	−81.3
South and Central America export	−7.8	−10.9	−13.3	−10.6	−21.1	−39.2
Percentage changes (%)						
World trade	−0.08	−0.11	−0.12	−0.23	−0.47	−0.87
China's import	−0.06	−0.08	−0.09	−0.56	−1.12	−2.08
NAFTA's export	−0.10	−0.13	−0.14	−0.44	−0.87	−1.63
South and Central America export	−0.11	−0.16	−0.19	−0.70	−1.40	−2.60

Table 8
Impacts of Biosafety Protocol on world and China's domestic production of soybeans and maize under alternative scenarios in 2010

	Soybean			Maize		
	I	II	III	I	II	III
In million US$						
World	3.1	4.2	4.6	8.5	17.3	33.4
China	4.1	5.4	5.9	10.8	21.7	41.0
NAFTA	−7.4	−9.6	−9.8	−20.6	−41.2	−77.3
South and Central America	−6.9	−9.7	−11.6	−7.5	−14.9	−27.7
Percentage changes (%)						
World	0.007	0.010	0.011	0.017	0.034	0.065
China	0.130	0.173	0.188	0.097	0.195	0.369
NAFTA	−0.052	−0.067	−0.068	−0.097	−0.193	−0.363
South and Central America	−0.055	−0.076	−0.091	−0.104	−0.206	−0.382

on China's domestic price of requiring the strictest of testing (difference between scenario II and III) would still be small.

When domestic prices rise in importing countries and domestic prices fall in exporting countries, there is an effect on production in each individual country, even though the overall effect on world production is small (almost zero—Table 8). When China's domestic price rises due to biosafety regulation, producers, seeing a higher price, respond by producing more. In contrast, in exporting counties, the lower domestic prices induce producers to cut back on production. Again, however, although the absolute amounts are relatively large, the percentage amounts are not.

Concluding remarks

In this paper we have sought to calculate the impact of the BSP on agricultural commodity trade in China and the world. Our results suggest that in absolute terms the BSP will require large investments internationally and will induce compliance costs, especially for those countries that do not currently have monitoring regulations or institutions to manage the flow of LMOs at their borders. Therefore, it is important to consider the fixed costs of investing in the system. This may greatly increase the burden to small countries that do not import every year.

Assuming the institutions get put into place, the BSP also will increase the cost of trade due to the requirements to monitoring and test international shipments as they leave exporting countries and as they arrive into importing nations. In absolute terms the amounts are not small, amounting for each commodity into the tens of millions of dollars. The results also show that the more stringent the policies, the higher the costs.

When focusing on the impacts of the variable compliance costs alone, it is possible to give our findings another interpretation. Given the large volume of flows of international commodities, and the relatively low cost per sample tested, an argument can also be made that the impact is fairly small—at least in percentage terms. Even under the strictest testing criteria, the direct cost per ton is relatively low. Trade flows are dampened, but also only marginally. Because producers and consumers react to the higher prices (due to testing), the final (direct and indirect) impact on prices is even lower—although its impact is different in exporting and importing countries. In short, such impacts in percentage terms—as a share of total trade flows; as a share of total production; as a share of total price—are small.

Considerations on the impacts of the BSP must also take into account preexisting national biosafety regulations. Our analysis compared the scenarios of no monitoring or testing for GMOs/LMOs at the border and after the implementation of the BSP. For countries with some biosafety regulation of their own, such comparisons may overstate the projected compliance costs of BSP. For instance, as we show, China already has a fairly comprehensive system of biosafety management and testing. Hence, if we compare the additional costs to implementing the BSP with the current costs of China's own domestic biosafety management program, when we use the less strict criteria for testing under the BSP, there is near no impact.

A caveat is needed here, especially when thinking about the lessons of the China case for the rest of world. Above all, it should be remember that compared to some developing countries, China's capacity to design and implement policies is much greater. The base from which China began to implement its biosafety policy is higher. Hence, both the upfront fixed costs and the marginal costs to China are likely to be less than in other nations.

Based on this type of analysis, there might also be a tendency to suggest that since the cost is low, why not ignore the BSP and allow for its approval using the strictest testing criteria. But there are reasons why from a scientific, economic and political-economy point of view that this may not be desirable. For example, one must question why it is that if the impact of the BSP under some of the most plausible testing options will have little impact, there should be a BSP at all. This is a serious question. We have shown that left on their own that countries such as China have taken seriously issues of biosafety and have already invested in a system that is providing almost all of the services at the same level of rigor that is contained within the BSP. From this point of view, it is true that such a document is of very little use to China itself. Therefore, an argument can be made the redundant agreements are wasteful and unnecessary.[10]

However, the ultimate lesson from the China study is that good policies that are science-based and that are designed to monitor but not obstruct can be implemented without being costly or disruptive. Countries, like China—that is those with long histories of being able to implement policies to protect their own economies—are likely to be neither hurt nor helped by international agreements that are reasonable. But, it is important to remember that other nations may need more help; and that it will be more costly.

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Appendix. Adjustments made to China GTAP database

Before we apply GTAP 6 for the current analysis of the impact of the BSP, we carefully examined its database and parameters for China and made a number of adjustments. The main ways that we adjusted the database are listed below.

(1) We aggregate 87 regions into 7 regions (China, Japan and Korean, Australia and New Zealand, North American Free Trade Area or NAFTA, South and Central America, European Union, and Rest of World). This aggregation reflects the major trade flows of soybean and maize among regions.
(2) We aggregated 57 sectors into 16 sectors, and then separated soybean from oilseeds and maize from coarse grains. The production and domestic consumption shares in 2001 are calculated from the FAO, 2004 database. The bilateral trade shares in 2001 among regions are from the UN COMTRADE database.
(3) On the input–output tables for China, we overcame some of the shortcomings in the GTAP database by taking advantage of data that have been collected by the National Development and Reform Commission. These data are collected from more than 30,000 households and include detail costs of production of major crops and livestock.
(4) On demand elasticities for China, we incorporated the most updated and empirically estimated price and income elasticities of demand for various foods in China for the base year (2001) into GTAP version 6. These are consistent (although updated) with those published in Huang and Chen (1999).
(5) Trade distortions. We adjusted both import and export tariff equivalents of agricultural commodities in the base year (2001) based on the results from a study by Huang et al., 2004a,b.
(6) The baseline is constructed by applying a recursive dynamic approach. We implement the simulation in two steps (2001–2005; 2006–2010) to reflect the change of endowments and actual performances in 2001–2005 in different countries and in the different periods. The baseline projection also includes a continuation of existing policies and the implementation of important policy events related to international trade as they are known to date. The important policy changes are: implementation of the remaining commitments from the GATT Uruguay round agreements; China's WTO accession between 2001 and 2005; EU enlargement.

[10] The story may be different in the case of other nations that need international treaties to push them to launch a new set of regulations; apparently, as our study shows, this is not the case in China.

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