LOW LEVEL PRESENCE OF GMO IN MALAYSIA'S IMPORT: THE ALTERNATIVE TOLERANCE AND ITS ECONOMIC EFFECTS

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Abstract: The commercial use of genetically modified organisms (GMO) is increasing in both developed and developing countries. Problems with the sale of GMO in international trade are also increasing given the diverse regulatory frameworks needed to ship GMO products globally. One of the problems is the asynchronous authorisation which has led to low level presence (LLP) of unauthorised genetically modified (GM) material in imported food and feed products. Under the current regulations in Malaysia, the presence of an unauthorised GMO in the marketplace is regarded as a regulatory non-compliance to which the Malaysian government has a zero-tolerance approach. The objective of this paper is to assess the economic effects of alternative LLP tolerances for unauthorised GMO products. The study is modelled on the economic effects of different management options for LLP situations based on tolerance levels. The study first developed an analytical model and from the data collected, simulations of effects under different scenarios; which a zero-tolerance LLP and a non-zero tolerance LLP were performed. The study found that Malaysia can benefit economically from adopting non-zero tolerance LLP approaches, especially given that a yearly average of four million metric tonnes of imported corn and soybeans could potentially be subject to trade disruption.

Keywords: Genetically modified organism, sustainability, low level presence, zero tolerance, welfare effects.

Introduction

The commercial use of genetically modified organisms (GMO) is increasing in both developed and developing countries. In 2018, 191.7 million hectares of GM crops (up from 189.8 million hectares in 2017) were grown by a total of 17 million farmers in 26 countries, of which 21 were developing countries and 5 industrial countries. The main GM crop was soybean which accounts for 50% of the global GM crop area followed by corn (30.7%), cotton (13%), and canola (5.3%). Herbicide tolerance has been the dominant trait of such GMO crops (46%), while stacked traits accounted for 42% of the global GM crop hectarage (ISAAA, 2018).

Since its first introduction for commercial cultivation in 1996, many countries have adopted a domestic regulatory framework that deals with the requirement for authorisation of the use of GM crops (Adenle *et al.,* 2013). Most of these countries impose conditions for domestic authorisation that involve an environmental risk or safety assessment before such crop is allowed to be commercialized or released into the environment (Brookes, 2008). Risk assessment procedures which the decision for authorisation will be based upon, are usually formulated in accordance with established guidelines produced by international bodies. In general, authorisations for commercialisation in every country happen individually at different timings (Smart *et al*., 2016). A distinction is commonly made between the purpose of the GM crop, that is whether it is intended for restricted use or to be released into the environment. Moreover, countries also make a difference between cultivating GM crop or applying it to the food and feed chain (Broeders *et al*., 2012), for example, raw or processed material.

Thus, at any time, there is a possibility that GM crop authorised in one country for cultivation or food and feed purposes, is yet to be authorised in other countries with which the country that has given authorisation trades agricultural commodities (Kalaitzandonakes, 2011). This is commonly known as asynchronous authorisation. Asynchronous authorisation can happen because the time taken for the approval process is different from one country to another or it may occur due to approval never having been submitted to or given by the countries that are involved in the import of agricultural commodities (Clapp, 2008). When trace amounts of this unauthorised GM crops are detected in grain or seed shipments, or in ingredients or finished food products, it can lead to trade disruptions if the importing country applies a zero-tolerance approach and rejects the shipments. From a trade perspective, this situation is called low level presence (LLP).

The rejection may result in costly fines, lost revenue on the total grain shipment, expensive testing, and clean-up, unsold or destroyed grain or seed, product recalls in importing countries and the loss of export market share as the importing country sources grain from another country (Stein & Rodríguez-Cerezo, 2010).

This paper attempts to assess the economic effects of alternative LLP tolerances for unauthorised GM crops in Malaysia. The next section provides a brief background about GMO crops and GMO regulations in Malaysia including zero-tolerance approach. Following that, the paper discusses the studies that have been conducted, its findings and analysis.

Background

Regulatory Framework for GM Crops

Demeke *et al.* (2006) regarded the Cartagena Protocol on Biosafety (CPB) which was adopted under the aegis of the United Nation's Convention on Biological Diversity (CBD) as central to the issues related with asynchronous approvals and LLP. The CPB encourages its members to make decisions on the import of GMO crops and products for release into the environment, in accordance with scientifically accepted risk assessments. The CPB also establishes methodological steps and points to be taken into account while carrying out the risk assessment as well as monitoring and enforcement mechanisms to guarantee the safety of GMOs once they are approved.

Malaysia ratified the CPB in September 2003 and since then has taken steps to ensure a domestic regulatory framework on biosafety was put in place. Subsequently, the Malaysian Biosafety Act was approved by the Parliament in 2007. The Act is drafted to be in line with national policies on biodiversity and biotechnology and covers only modern biotechnology activities. It is neither against modern biotechnology nor pro modern biotechnology but it works as an enabling piece of legislation to ensure the safety of all GMO applications (Arujanan & Singaram, 2018). The purpose of the Act is not only to protect human health but plant and animal health and the environment and biodiversity. The act regulates the release, importation and contained use of GMOs including its products.

The Act came into force on 1st December 2009 and was quickly followed by the Biosafety (Approval and Notification) Regulations 2010 on 1st November 2010 to implement the Act. The Act and regulations represent a new regulatory system specifically to govern GMOs and its products and fulfil Malaysia's obligation under the CPB.

The nature of the biosafety institutional framework diverges from one country to another country. Malaysia is operationalizing a centralized institutional framework whereby a single department is assigned to handle all the applications, provide administrative support for the risk assessment and decision making processes including organizing inputs from relevant agencies and public. Some countries have placed administrative responsibilities for biosafety in various government departments depending on the type or intended use of the GMOs in question (Andrew *et al.*, 2018).

Authorized GMOs in Malaysia

Under the Malaysian Biosafety Act, release activities mean any intentional introduction or release of GMOs and its products into the environment. These activities include supply or offer to supply for sale or placing on the market. Any application for authorisation for release activities including importation of GMOs must be submitted to the National Biosafety Board (NBB) together with the prescribed fees. The NBB, after having considered the recommendations of the scientific body and the comments from relevant government agencies as well as the public, will make a decision on whether to grant approval to the application. The authorisation process takes a maximum of 180 working days to be completed (Ramatha, 2011). As shown in Table 1, Malaysia has approved 30 GM events for corn and soybeans for the purpose of food, feed, and processing up to 2018. The number of approvals granted is still low if compared to those of its key trading partners.

Malaysia imports around three million metric tonnes of corn and 500 thousand metric tonnes of soybeans annually. The origins of these products are mostly from the United States, Brazil, and Argentina, which are among the top producers of corn and soybeans in the world. About 80% of corn and soybeans cultivated in these countries are genetically modified (refer to Table 2).

Given current import trends and the status of GM product approvals, Malaysia must not rule out the possibility of unauthorised GM corn or soybeans being present in the local market.

Zero Tolerance Policy

Countries are diverging when it comes to strategies used to address LLP issues. These strategies can be no specific LLP policy, zero tolerance or technical zero policies, or a policy with a low threshold for LLP. Generally, a zero-tolerance policy or approach implies that ingredient or component for any import of food or feed products cannot contain even trace amounts of GM materials for which authorisation has not been given by the importing country (Matsuo & Yoshikura, 2014). In many countries, a zero-tolerance policy is applied when dealing with unauthorised GM crops in its territory. This statement is consistent with the result from the

Table 1: Approved GM events for corn and soybeans as of 2018

Type of crop	Malaysia	Key Trading Partners			Global
		Argentina	Brazil	USA	
Corn	19	51	52	43	238
Soybeans	11	17	18	25	41
Total GM events	30	68	70	68	279

Source: International Service for the Acquisition of Agri-biotech Applications (ISAAA, 2018).

Table 2: Exports of corn, soybean by GM producing countries to Malaysia, 2014 (metric tonne)

Country	Share in Global Production		GM Share in Production		Export to Malaysia	
	Corn	Soybean	Corn	Soybean	Corn	Soybean
Argentina	3.2%	17.4%	80%	99%	1,579,032	43,124
Brazil	7.7%	28.3%	79%	83%	1,594,505	62,482
United States	34.8%	34.9%	93%	94%	55,982	223,383
Total					3,229,519	328,989
Share from Malaysia's total import 2014					84.5%	57%

Source: FAOSTAT (2017), and Brookes and Barfoot (2017)

survey conducted by the Food and Agriculture Organisation (FAO) in 2013, where 46 out of 64 countries took part in a survey (or 72%) indicated that they will apply a zero-tolerance approach in the event of the LLP of GMO crops (Atici, 2014).

Malaysia together with several other developing countries at the moment does not have a dedicated policy to address unintended, low levels of unauthorised GM materials that could be found in imported grain, food, and feed products. The existing law in Malaysia has a zero-tolerance approach hence the presence of any unauthorised GM crop in the Malaysian marketplace is regarded as a regulatory non-compliance. In this regard, grain or seed shipments that contain even trace amounts of unauthorised GM crop product would be classified as a non-compliance and this will prompts a management strategy involving the removal of LLP of said GMO products. Based on Malaysia's response to the FAO survey (Atici, 2014), no incident of LLP has been recorded so far. Despite that, the concern remains about the practicality of a zero-tolerance approach in managing LLP situations.

From the trader's perspective, the use of a non-zero tolerance LLP policy is best (Ryan & Smyth, 2012). However, this policy is only practical if it balances risks and other economic considerations (Marcoux *et al*., 2013)

Materials and Method

Gruère (2016) developed a model to assess the most important factors to consider when setting up LLP tolerance or threshold. He identified three factors that matter: the total surplus or market effects; the perceived safety or risk avoidance effect; and the cost of implementation.

However, there are few other assumptions applied to this type of analytical model. For instance, since Malaysia is a small country, it can be assumed to be a price taker on the international market. It is also assumed that there is a linear inverse demand for corn or soybean products in Malaysia, and a linear supply. From the perspective of regulatory authorities, as long as the shipments contain corn or soybean that originate from GM crop producing countries, the possibility of new GM crops entering domestic market and to cause safety concerns remain positive (Kalaitzandonakes *et al*., 2011). Finally, perfect or strict enforcement is assumed to be in place as a benchmark.

In modelling the framework, it is assumed that, Malaysia is importing corn or soybean products from a GM corn or soybean producing country, for example, Country A. At time t_1, a new GM corn or soybean event is authorised in Country A, but not yet in Malaysia. Argentina is also a country where GM corn or soybean is mixed in with other GM crop commodities. During the time regulatory process for approval takes place, say until time t_2, Malaysia has to look for a substitute or a different type of products, presumably a non-GM corn or soybean product, either in Country A or another country to meet its domestic demand.

For comparison purposes, let's say that Malaysia has to purchase the non-GM corn or soybean product at a price higher than the price of GM corn or soybean product purchased from Country A which has mixed GM crop commodities.

Rooted in the above framework, Malaysia, as an importing country, is expected to make a decision from a social welfare perspective based on the following formula –

$$W = \left[\frac{(b-p)/Q}{2} + \frac{(cQ^2)}{2}\right] - [CS(\tau) + CT(\tau) + CO + CA]Q \quad (1)$$

where W denote basic welfare ; b denote demand parameter; c denote supply parameter; p denote expected price under the existing policy; Q denote quantity of products measured in kilogram (kg); CS denote cost of taking sample; CT denote cost of GM testing; CO denote staff related costs; CA denote administrative related costs; and τ denote tolerance level. Total welfare, as expressed in the above formula, can be segregated into two sections: first, the Marshallian surplus; and second, the costs of regulation to the government.

Total surplus is derived after the consumer surplus and producer surplus. However, since Malaysia does not produce corn and soybean for domestic consumption during the observed period, only estimation for the consumer surplus was included in the findings to represent the total surplus.

The expected price is one of the main components to compute the consumer surplus. In order to derive the expected price, the study computed for the price of the GM or mixed products, the price of non-GM products, the share of GM corn or soybean products in imports and the probability of rejection of shipments which is determined based on LLP tolerance level.

The total costs were estimated based on information provided by relevant government agencies that are directly involved in GMO monitoring and enforcement activities specifically to detect the presence of unauthorised GM events at five key entry points in Malaysia. In providing the information, the agencies concerned acknowledged the government current policy towards LLP situation (that is zero-tolerance approach) and limited resources they had (that include manpower, financial, equipment and technical capacity) to meet those needs. Therefore, the information has to take into account activities that have been done and what they were actually planning with the available resources.

A template has been prepared for this purpose as a guide for the agencies to provide the information. The template consists of six sections covering:

i) emolument costs related to LLP monitoring and enforcement activities;

ii) training expenses for the staff involved in the LLP monitoring and enforcement activities;

iii) costs for sampling, confiscation, and detection of GMO;

iv) costs for storage and disposal of GMO samples;

v) costs for delivery and transportation for GMO samples; and

vi) other costs directly related to monitoring and enforcement of LLP.

$CS(\tau)$, which is the costs involved in taking the sample, correlated with the tolerance level since for a given concentration level, when the tolerance level is high, it does not require a large sample (Gruère, 2016).

$CT(\tau)$ represents the costs of testing, also depends on the tolerance level. It is assumed that when the tolerance level is low, the cost of testing becomes more expensive due to level of detection and analysis required or simply can be summarized as $CT(\tau<1\%) > CT(1\%<\tau<5\%) > CT(\tau> 5\%)$. For the testing costs, Gruère & Rosegrant (2008) has provided an estimation of cost values that can be assigned to the tolerance level as follows: 5% tolerance level for $0.1 per tonne; 2.5% for $0.5 per tonne; 1% and 0.9% for $1 per tonne; 0.5% for $1.5 per tonne, and 0.1% for $2.5 per tonne.

Results and Discussion

The study analysed the global production of corn and soybean and determined the GM shares of these products in selected producer countries. The analysis also looked into the portion of GM or mixed products in corn and soybean imports to Malaysia. Figure 1 illustrates the composition based on the volume of imports of corn and soybean from the year 2010 to 2014. For the purpose of this analysis, data on imports were segregated according to their source. The exporters can be GM producing countries or non-GM producing countries. Using the information on GM shares and volume of imports by Malaysia for corn and soybean products from individual GM producing country, GM portion of these imports can be determined. From the figure, it was estimated that the GM portion in imports of corn by Malaysia for the years 2010 to 2014 range between 57% and 66.1%. Meanwhile, for soybean, the portion was estimated to be high, at more than 90% on average for the same period. These findings on the GM portion in Malaysia's
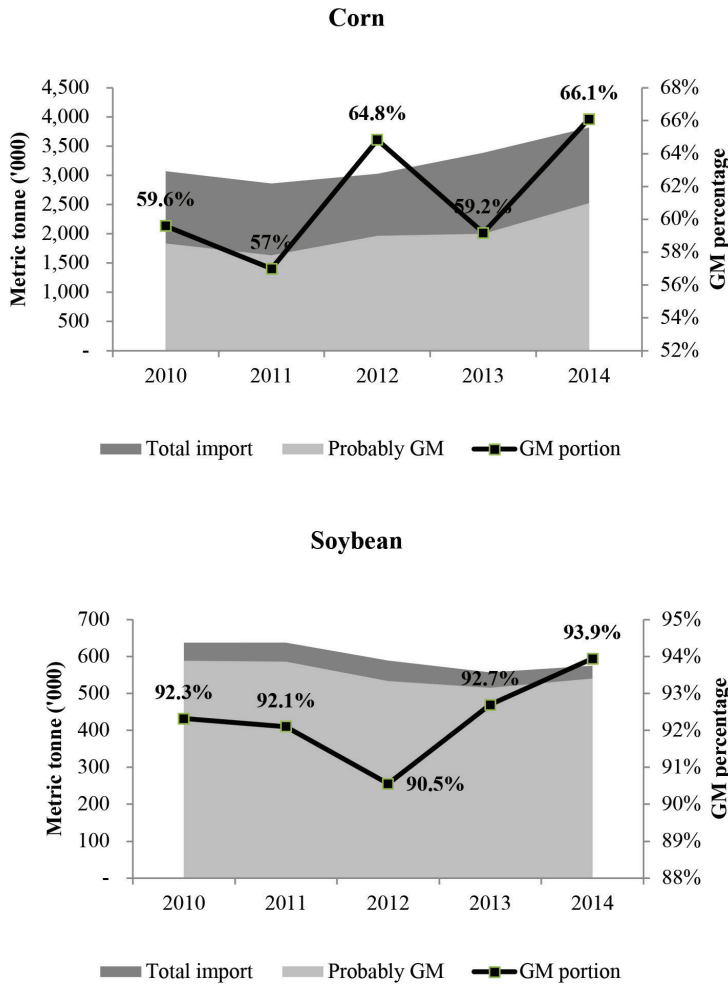
Figure 1: Non-GM versus likely GM in Malaysia's import for Corn and Soybean, 2010-2014

corn and soybean imports show that key GM corn and GM soybean producing countries were among Malaysia's major trading partner for these products.

The expected price per kilogram was computed for different LLP tolerance levels and then used to estimate the effects on consumer surplus. When LLP tolerance increased from 0% to 5%, the expected price for corn reduced between 0.5% and 1.5% whereas, for soybean, it reduced between 0.1% and 0.4%.

Variations in the expected price for corn and soybean from the year 2010 to 2014 were partly due to changes in the price premium or the difference between the price of GM and non-GM products over that period.

Table 3 shows the simulation results for the consumer surplus based on different LLP tolerance levels. The consumer surplus is derived after the difference between the price of the imported product and the expected price for the same product then multiplies with the volume of imports.

For corn, it can be interpreted that the consumer surplus will increase when the LLP tolerance level increases. In 2014 for example, the consumer surplus increased from US$1.9 million to US$8.8 million if LLP tolerance level

is changed from 0% or zero-tolerance to 5%. Likewise, the consumer surplus for soybean also increases with the increase of the LLP tolerance despite the negative surplus.

In Table 3, when the LLP tolerance increased from 0% to 5%, the consumer surplus for soybean increased by 0.6% in 2014. The consumer surplus for soybean is negative partly due to a higher expected price for soybean compared to the price of the imported product. The expected price can vary depending on the difference between the price of GM or mixed product and the price of non-GM product.

The cost incurred by the government for LLP related monitoring and enforcement activities under the existing LLP management framework was estimated at around US$180 thousand per annum (Table 4). Slightly more than half (58.9%) of the costs went to sampling, confiscation and detection activities.

These activities used more resources compare to the rest. Precise GMO testing and detection, for example only can be performed in the laboratory that is equipped with the latest equipment. About 30% of the total costs were allocated for staff emolument and training.

In determining the costs for emolument, details about the staff's monthly salary and hours spent on LLP related monitoring and enforcement activities were obtained. Other related costs include storage and disposal, transportation and rental fees.

All GMO samples need to be stored properly and disposed in accordance to the standard procedures. GMO samples need to be transported or delivered from the place where the sample was taken to the place where it will be kept before sending it to the laboratory for analysis. Although the costs were minimal, these activities are integral and part of the monitoring works to detect the presence of unauthorised GM crops.

Table 3: Consumer surplus based on different LLP tolerance

| LLP Tolerance | Consumer Surplus (in Million US$) | | | | | | | | | |
| | Corn | | | | | Soybean | | | | |
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
0%	38.1	34.3	(25.2)	11.7	1.9	0.7	(27.5)	(26.6)	(23.8)	(26.3)
0.1%	38.2	34.5	(25.2)	12.0	2.1	0.8	(27.4)	(26.5)	(23.8)	(26.3)
0.5%	38.7	35.1	(24.8)	13.0	2.9	1.0	(27.1)	(26.2)	(23.4)	(26.2)
0.9%	39.2	35.8	(24.4)	14.1	3.8	1.3	(26.8)	(25.9)	(23.1)	(26.1)
1%	39.3	36.0	(24.3)	14.4	4.0	1.3	(26.8)	(25.8)	(23.1)	(26.1)
3%	41.2	38.8	(22.8)	19.0	7.7	2.4	(25.6)	(24.6)	(21.8)	(25.8)
5%	41.8	39.7	(22.3)	20.3	8.8	2.7	(25.2)	(24.3)	(21.4)	(25.7)
Difference (0% to 5%)	3.7	5.4	2.9	8.7	6.9	2.0	2.3	2.3	2.4	0.6

Table 4: Estimated costs for GMO monitoring activities

Activities	Estimated cost (US$)	Percentage
Sampling and testing	106,461	58.9%
Staff costs	55,770	30.8%
Other related costs	18,541	10.3%
Total	180,772	100%

The analyzed data on changes in the total surplus and costs incurred to monitor unauthorised GMO presence are the main elements to estimate the total welfare effects. The estimation results are expressed in total welfare under zero-tolerance approach and several non-zero LLP tolerance options.

Although the results do not claim to be precise estimates of the economic effects from the change in LLP tolerance level, but it can serve as a benchmark value in designing the threshold level for LLP management strategy in Malaysia. Table 5 shows the welfare effects for corn and soybean in the case of 0%, 0.1%, 0.5%, 0.9%, 1%, 3% and 5% LLP tolerance levels. It demonstrates relatively consistent change in the total welfare when the tolerance levels increase from 0% to 1%.

For corn, from zero-tolerance (or 0% LLP) to 1% LLP tolerance, the total welfare is expected to increase from US$12.05 million to US$13.82 million per year whereas for soybeans, under the same scenario, the total welfare changed from –US$20.78 million to –US$20.13 million per year. Thus, the maximum change in the total welfare for a 1% change in LLP tolerance was 14.7% for corn and 3.1% for soybean.

The percentage change was higher if the tolerance levels increase further to 3% and 5%. It can be observed that the change in total welfare for corn is 39.1% and 46.6% for the changes in LLP tolerances from 0% to 3% and from 0% to 5% respectively. The similar trend is also noticeable for soybean but with a smaller percentage value, 8.2% and 9.7% for LLP tolerances change to 3% and 5% respectively.

Figure 2 graphically presents the welfare change across scenarios as represented by the darker line. The line also demonstrates the change in total welfare at different LLP tolerances for the combined products. The comparison across scenarios shows that going from 0% to 5% tolerance increases the welfare by 87.4%. In fact, when the tolerance level increased from 0% to 3%, the welfare has changed notably by 73.3% or US$6.4 million per year, a different of US$1.23 million from 5% tolerance.

The lighter line in the figure is representing the probability of rejection. The number which was adapted from Gruère (2009) explains the probability of the products get rejected by the importing countries under certain LLP tolerance measures as a precaution that the products might contain unauthorised GM materials. Under the GM-ban scenario, the probability of rejection can be as high as 100% depending on the origin of the imported products.

On the contrary, an all-pass scenario can minimise the probability of rejection as low as 0% subject to clearance by authorities in charge

Table 5: Welfare effects simulation (in million US$)

Effect	Crop	LLP tolerance						
		0%	0.1%	0.5%	0.9%	1%	3%	5%
Surplus effect	Corn	12.14	12.32	13.00	13.69	13.86	16.78	17.67
	Soybean	(20.69)	(20.63)	(20.39)	(20.15)	(20.09)	(19.07)	(18.76)
Cost of implementation	Corn	0.093	0.093	0.058	0.040	0.040	0.022	0.007
	Soybean	0.087	0.087	0.054	0.037	0.037	0.020	0.007
Total welfare change	Corn	12.05	12.22	12.94	13.65	13.82	16.76	17.66
	% change from 0%		1.4%	7.4%	13.3%	14.7%	39.1%	46.6%
	Soybean	(20.78)	(20.72)	(20.45)	(20.19)	(20.13)	(19.09)	(18.76)
	% change from 0%		0.3%	1.6%	2.8%	3.1%	8.2%	9.7%
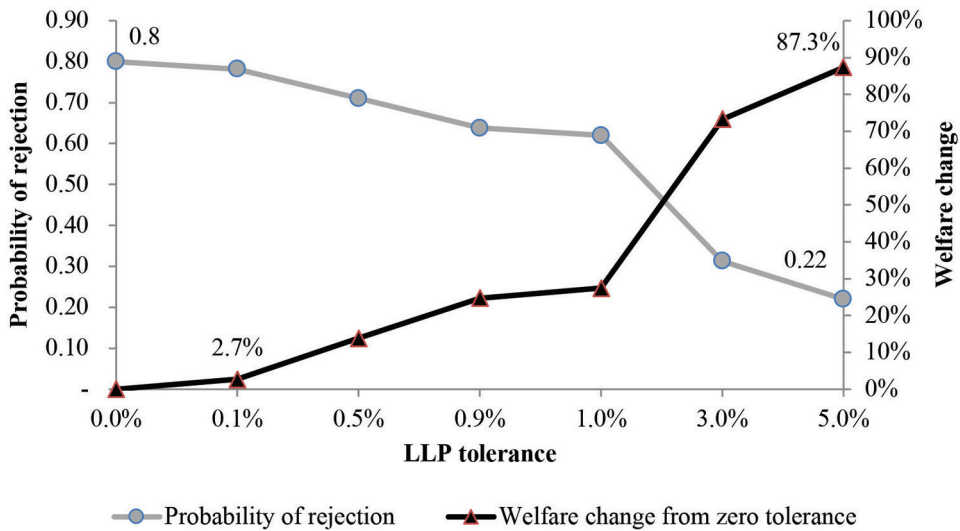
of laws pertaining to the products. In between of these two scenarios, a country can choose to regulate the use of GMO and either to tolerate or not to tolerate an LLP situation.

If the country decides to tolerate, the selection of tolerance level will have an impact on the probability of rejection. In Figure 2, it shows how the probability of rejection corresponds to LLP tolerance. The probability that the products get rejected going down from 0.8 to 0.22 when LLP tolerance increases from 0% to 5%. The same pattern in the welfare change also observed in the probability of rejection when it drops drastically from 0.62 to 0.31 as the tolerance level increase from 1% to 3%.

Conclusion

The increasing trend of GM crops commercialization can translate into more GM crop products being imported into Malaysia. Concerns always arise on the authorisation status of these GM crop products in Malaysia. In practical, it is difficult to completely prevent LLP incidents from happening although best management practices are strictly followed. Considering Malaysia is an importer of corn and soybean products from major GM producing countries, the application of a zero-tolerance

approach for LLP may need a review in term of its practicality.

Regardless of the LLP management options, the presence of an unauthorised GM product can have significant economic costs. For instance, the study showed that the choice of LLP tolerance significantly affects cost and welfare. Thus, the question for decision makers is whether the risk prevention associated with zero-tolerance is worth the potential additional cost in an LLP situation in this case. This means that the choice of zero tolerance over non-zero tolerance level is justified if regulators believe that the risk value of imports of maize or soybean supplies with 5% LLP of unauthorised GM materials increases significantly compared with a zero-tolerance for LLP.

Although it is not possible to reach final conclusions without comprehensive information that illustrates the risk of using GMOs, the discussion in this document implies that there is a substantial likelihood for risk aversion in society to reduce or abolish the benefits of using GMOs for others. With a view that different countries at diverse phases of development have different priorities regarding the risks associated with an increase in welfare, the ability of one country to dictate the ability of another country to benefit from the use of GMOs may lead to a decrease in potential welfare gains.

If minimizing delays in the regulatory process and maximizing trust unambiguously increases overall welfare, choosing a tolerance level will balance perceived risks and costs, and should be chosen based on local circumstances.

Acknowledgements

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