An Economy-wide Analysis of GM Food Labeling Policies in Taiwan

by

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Abstract

The development of agricultural biotechnology offers the opportunity to increase crop production, lowers farming costs, improves food quality and could reduce costs to consumers. For the food importing economies, the import quantities as well as prices will be affected through world market as the production technology of GM crops is adopted by the exporting countries. Many sectors will be affected by the use of these crops through vertical (or backward) and horizontal (or forward) linkages. The purpose of this paper is to develop an economy-wide quantitative assessment of the economic impacts of the introduction of GM products with and without labeling. The modeling framework used in this analysis is TAIGEM (Taiwan General Equilibrium Model), a multi-sectoral computable general equilibrium (CGE) model of the Taiwan's economy which is derived from ORANI model (Dixon, Parmenter, Sutton and Vincent, 1982). TAIGEM is amended by splitting corn and soybeans into GM and non-GM varieties. It also endogenizes the decision of producers and consumers to use GM vs. non-GM corn and soybeans in their intermediate uses and consumption, respectively. We also consider the consumers' acceptance of GM food so that the mandatory labeling policy can be examined. Our simulation results indicate that the most extreme import ban on GM crops would be very costly in terms of total production values, ranging from NT$ 40 to 90 billions per year.

Keywords: Computable General Equilibrium (CGE) Model, Genetically Modified Crops (GM crops), Labeling

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1. Introduction

The introduction and adoption of agricultural biotechnology offers an opportunity to create cost saving (or revenue enhancement) through productivity increases or quality improvement. The economic evaluation of introducing genetically modified (GM) product requires modifications to the traditional analysis of technological changes to account for the potential market power of the private innovating firms that made the investments in GM technology and to address the demand response to the introduction of this technology.

Recently Fulton and Giannakas (2004) develop a framework where these modifications are introduced and where their feedback on the rest of the system is captured. They examine the system-wide effects of the introduction of GM products with and without labeling. However, many sectors have been affected by the use of GM products through vertical (or backward) and horizontal (or forward) linkages. The purpose of this paper is to develop an economy-wide quantitative assessment of the economic impacts of the introduction of GM products with and without labeling. The basic framework used in this analysis is TAIGEM (Taiwan General Equilibrium Model), a multi-sectoral computable general equilibrium (CGE) model of the Taiwan's economy which is derived from ORANI model (Dixon, Parmenter, Sutton and Vincent, 1982).

We use Taiwan's import of GM products as an example to provide an economy-wide assessment of the impacts of labeling policy. Until now Taiwan haven't commercialized any GM crops production. However, Taiwan is highly dependent on importing grain products from the world market. The import quantity as well as price will be affected through the world market as production technology of GM crops is adopted by exporting countries. When the GM crops are imported to Taiwan as inputs for many agricultural and food products, other sectors will also be affected by their intermediate use of GM crops through vertical (or backward) and horizontal (or forward) linkages.

A voluntary labeling of GM product was introduced by the Department of Health in Taiwan from 1 January 2001, while a mandatory labeling of designated foods was introduced in three stages according to the degree of processing of the food products starting from January 2003. Under the new labeling requirement, food containing more than 5 per cent of GM soybean or corn in the finished products has to be labeled as food with GM ingredient. On the other hand, food containing less than 5 per cent of GM soybean or corn is regarded as food with non-GM ingredient.

This model and its dataset are amended by splitting corn and soybeans into GM and non-GM varieties. The decisions of producers and consumers to use GM vs. non-GM corn and soybeans in their intermediate uses and final consumption are endogenized. We also consider the degree of consumers' acceptance of GM food so that the potential impacts of mandatory labeling policy on GM food may be examined. Specifically, TAIGEM and its dataset are amended in three steps. First, we separate soybeans and corn from other crops sectors in the Input-Output Tables. Next, we split the soybeans, corn, and their corresponding processing sectors into sectors with GM and non-GM ingredients. Thereby, we allow for a choice between GM and non-GM in production and consumption.

The paper is organized as the follows. In the next section, a general review about the production and trade situation of GM soybeans and GM corn is provided. The third section presents the model and scenarios that will be used in the policy assessments. The impacts of alternative GM soybeans and GM corn policy strategies will be discussed in the fourth section. The final section provides concluding remarks and suggestions for policy actions.

2. GM Crops Development

The purpose of this section is twofold. First, we provide a general overview on the world production on GM soybeans and corn. Second, we propose a method to compute the country-wide trade flow table on GM soybean and corn, because world trade statistics does not provide information on exports and imports of GM soybean and GM corn.

2.1 World production

Around the world, there were virtually no GM crops in the field before 1990s. Nowadays, the estimated global area of transgenic or GM crops for 2001 is already 52.6 million hectares in 13 countries (ISAAA, 2002). The increase between 2000 and 2001 was 8.4 million hectares and represents a 19 per cent increase. Between 1996 and 2001, the total area of GM crops grew about 30 times.

Geographically speaking, production of GM crops is currently concentrated in just a few countries while more countries are experimenting new traits. For 2001, 99 per cent of GM crops are produced in four countries, namely US (68 per cent), Argentina (11.8 per cent), Canada (6 per cent) and China (3 per cent). In crop-wise, GM soybean is the most popular one, accounting for more than 60 per cent of global GM crop production area. GM corn comes next, accounting for 19 per cent (ISAAA, 2002). The same report also indicates that the two major GM traits in 2001 are herbicide tolerant crops, accounting for 77 per cent of all GM crops, while Bt maize accounts for 11 per cent.

In terms of trade, it is obvious that the world's top three GM crop producing countries are mainly all major agricultural exporters, i.e., the U.S., Canada and Argentina. China is growing very fast in GM crop production but mostly for domestic consumption (Huang et al, 2002). The majority of GM agricultural products in international trade are crops. Although the estimated global planting acreage of GM crops is around 52.6 million hectares, there is yet no available statistics on the global trade volume of the GM product. However, it is possible to estimate the global trade volume of GM products with information available from various sources. A compilation procedure is presented as follows.

2.2 GM soybean export

The 2000/2001 global trade volume of soybean has reached 54.88 million metric tons (mt). The top three exporters were U.S. (49.4 per cent), Brazil (27.5 per cent), and Argentina (13 per cent) (USDA, 2002). These top three GM soybean growing countries exhibit similar trade patterns. U.S. exports about 36 per cent of its soybean production, followed by Canada's 33 per cent and Argentina's 27 per cent (compiled from USDA, 2002).

ISAAA (2002)'s data indicated that, in 2001, GM soybean made up 46 per cent of global soybean planting areas. Statistics from USDA (2002) showed that the global production of soybean was 174.94 million tons in 2002. Before converting planting acreage into production volume, difference in productivity must be taken into account. Drawing from the findings of a Canadian study, Hategekimana (2002) reported that preliminary results showed that GM soybean is about 3 to 4 per cent more productive than the conventional soybean. Shoemaker (2001), on the other hand, reported a yield difference around 1 to 5 per cent. With these results, a simple average of 4 per cent is assumed for the share of GM soybean in the global soybean production. Our calculation results show that in 2001 GM and non-GM soybeans production were about 84 million tons and 92 million metric tons, respectively. The ratio of tonnage between GM and non-GM soybeans is therefore 47.5 to 52.5 per cent. These percentages are slightly higher than ISAAA's 2002 figure of 46 per cent.

Assuming that GM and non-GM soybeans have an equal opportunity (or probability) of being exported, the trading volume of GM soybean can be approximated. Once again, using USDA (2002) statistics, the global soybean trade amounted to 54.88 million metric tons in 2001. Based on the above assumption, the global GM soybean trade volume of 26 million tons was obtained. In percentage term, 47.5 per cent of soybeans traded in the world market belong to the GM variety.

Among the three major soybeans exporting countries, Argentina is worthy of mentioning. After taking into account the productivity factor, over 98 per cent of soybean harvested was GM variety. Consequently, Argentina exports about 13 per cent of the global trade volume. As for the world's largest soybean exporter, the U.S., NASS (2002) reported a GM share of 74 per cent in acreage, which may be converted into 77 per cent in production. Again, assuming equal probability of export, around 21 million metric tons of GM soybeans are exported by the U.S. Therefore, the U.S. and Argentina together account for roughly half of global soybean trade volume.

2.3 GM corn export

In the case of corn, per hectare yield varies greatly. Hategekimana (2002) reported that GM corn yield is 4 to 12 per cent higher than the traditional corn production. Monsanto (2002) reported a discrepancy of 13.1 bushels per acre. Compared with the average yield of 119 bushels per acre during the period 1990~1995, this discrepancy may be translated into an 11 per cent increase (Dittrich, 2002). Taking a simple average of these percentages, a 9.5 per cent yield difference is used in the calculation of trade volume.

ISAAA (2002) reported that biotechnology varieties made up 19 per cent of global corn planting area. The USDA (2002) statistics indicated a global production of 585.69 million metric tons. With the difference in unit yield, it was estimated that total world production was divided into to a GM portion of 20 per cent and a non-GM portion of 80 per cent, which were equivalent to 117 million metric tons of GM corn and 469 million metric tons of non-GM corn, respectively.

World's top three corn exporters in 2001 were U.S. (64 per cent), Argentina (15 per cent) and China (9.6 per cent) (USDA, 2002). Again, assuming GM and non-GM corn have equal opportunities to be exported, these numbers suggest that at least 1.7 million metric tons of GM corn are exported by Argentina. U.S. farmers harvest 26 per cent of cornfield with GM varieties in 2001 (NASS, 2002), doubling that of Argentina. Using the same calculation, it can be estimated that around 28 per cent of U.S. corn export is GM variety, which in absolute terms is about 14 million metric tons.

As for our case study in Taiwan, soybean and corn are mainly imported for human consumption and animal feed processing. A major portion of soybean and corn imports flow into the processing sectors and are used for producing animal feed, oil and fats, dairy products, or other processed foods. According to the latest Input-Output Table published by Directorate General of Budget Accounting and Statistics (1999), the total domestic output value of Taiwan's soybeans was NT$ 9 million, which are all non-GM variety. In the same year Taiwan imported NT$ 16.8 billion of soybeans. If we use the previously estimated export proportion of GM soybeans, approximately half of these imports should be GM soybeans.

3. CGE Model and Scenarios

The modeling framework used in this analysis is a multi-sectoral computable general equilibrium (CGE) model of the Taiwan's economy derived from ORANI model (Dixon, Parmenter, Sutton and Vincent, 1982). It is designed for conducting comparative static analysis, i.e., for projecting the impact of an external shock on the economy at a point in time.

3.1 Model structure

First, on the supply side, the CGE model allows each industry to produce several commodities, using domestically produced inputs, imported materials, labor of several types, land, capital, energy of several types, and "other costs". Commodities destined for exports are distinguished from those for local use. The multi-input, multi-output production specification is kept manageable by a series of separability assumptions.

A cost-minimization behavior by producers is assumed, implying that each factor is demanded so that marginal revenue product equals marginal cost, given that all factors are free to adjust. The input demand of industry production is formulated by a five-level nested structure, and the production decision-making of each level is independent. The first level depicts the labor composition based on a CES function of various types of vocations. It also contains the aggregation of intermediate inputs from domestic and imported inputs by using a CES aggregation function. The second level describes the composition of primary input from labor, land, capital, and other inputs. It is also aggregated under the CES type of specifications.

At the third level, the commodity composition are specified as a Leontief production function of primary inputs and other intermediate inputs. Consequently, they are all demanded in direct proportion to the industry activity at the fourth level. At the fifth level, each commodity is allocated into the domestic and export market governed by constant elasticity of transformation (CET) transformation frontier.

On the demand side, the model assumes that the utility function takes the nested form. Households act as price takers and maximize their utility functions subject to budget constraints. The form of the household's utility functions is the Klein-Rubin function, also known as the Linear Expenditure System (LES) function. In the LES function, there is substitution between different goods and the goods are a composite CES aggregation of domestic goods and imported goods

3.2 Model extensions

The model is amended in three steps. First, we separate soybeans and corn from the crops sectors. Next, we split the soybeans, corn, and their corresponding processing sectors into GM and non-GM foods. Thereby, we allow for a choice between GM and non-GM in production and consumption.

In the model we endogenize the decision of producers in adopting GM vs. non-GM varieties as their inputs. Intermediate demands for each composite commodity (i.e., GM plus non-GM) are held fixed as proportions of outputs by using a Leontief production function specification. By doing so, the initial input-output coefficients remain fixed, but for GM-potential varieties, a choice is introduced between GM and non-GM varieties by use of a CES function with a certain degree of substitution possibilities. Other intermediate input demands remain in fixed proportions in relating to their output. Figure 1 illustrates our nested structure. In our empirical analysis, the input-output choice is endogenized in four sectors: edible oil and fat; feeds; processed foods, and livestock. In our empirical analysis, the input-output choice is endogenized for four sectors, i.e., "Edible oil and fat"; "Feeds"; "Processing foods", and "Livestock".

Similarly, the decision for final consumption of each composite good is an endogenous choice between GM and non-GM varieties for GM-potential commodities. We allow for substitutions among different goods. The GM-potential goods are composted under a two-layer system. The first layer is a composition of domestic and imported goods and the second one a CES aggregation of GM goods and non-GM goods. Non-GM goods have a simpler aggregation structure and are composed of imported and domestic goods. Figure 2 depicts the choice between GM and non-GM varieties in final consumption.

To sum up, the salient feature of our extended model is that the decision of producers to use GM or non-GM varieties as intermediate inputs into the production and processing procedures are endogenized. Similarly, final consumption is also endogenized so that consumers could maximize their utilities by choosing between GM-potential and non-GM goods.

3. 3 Data specification

The database was compiled from the 160-sector Input-Output Tables of 1999 published by the Directorate General of Budget Accounting and Statistics Executive Yuan. In our empirical study, we aggregate the input-output table into 18 sectors, which includes 7 primary agriculture sectors (paddy rice, other crops, other special and horticultural crops, livestock, agricultural services, forestry, and fish) and 4 agricultural processing sectors (edible oil and fat, animal feeds, processed food, and beverages). The remaining 7 non-agricultural sectors are respectively the energy and mineral products, leather products, lumber and by-products, chemical industry, other industry products, transportation, and services.

In the primary sector, we separate the source of supply into domestic and imports. For the domestic supply, the shares of GM soybean and GM corn are zeros because there is no GM soybean and GM corn production in Taiwan. As for imports, the shares of GM soybean and GM corn are 50 per cent and 30 per cent, respectively.

After converting to the proportion with the imported value of the other crops, the shares of GM soybean and GM corn in imported other crops are 19.21 per cent and 12.05 per cent.

Next, in the food processing sectors, the oil and fats sector used NT$ 14.63 billion of soybean and corn in processing. Among them, NT$14.2 billion comes from soybeans. Since 50 per cent are assumed to be of GM varieties, there are approximately NT$ 7.11 billion of GM soybean processed in this sector. The remaining NT$ 0.4 billion comes from corn, of which 30 per cent are GM-varieties. So approximately NT$ 0.122 billion of GM corn are processed each year. This amounts to the average share of 49.45 per cent [i.e., (7.113+0.122) /14.63 = 49.45 per cent] for GM products in the oil and fats sector. The estimation is the same for all other food processing sectors. Table 1 provides the shares of GM soybean and GM corn in GM-potential commodities in the primary and processing sectors.

3.4 Simulation design

Before conducting our simulation, we need to update the database from 1999 to 2002 in two aspects. First, we update the macro economic indicator, such as GDP, consumption, investment, and government expenditure. Second, we need to differentiate the prices of food products between GM and non-GM varieties. We amended the domestic price of GM varieties according to Hsu et al. (2000) that Taiwan's corn and soybean prices would, respectively, reduce by 14.55 per cent and 3.2 per cent once GM soybean and GM corn are imported**.**

Three policy scenarios are simulated based on our updated model for 2002. They are described as follows:

Scenario 1 (S1): Mandatory labeling of GM-contains.

The first scenario investigates the impact of the new regulation on mandatory labeling of imported GM soybeans and GM corn that came into effect in January 2003. We assume that information on any GM-contains food product can be recorded and passed along the food marketing chain. Under such a traceability system, we could distinguish GM-contains from conventional foods.

The traceable mandatory labeling policy is simulated as adding a service charge required for GM-contained food production. According to a study by Vandeberg et al (2000), the IP identification cost for corn and soybean in the U.S. is about 3~9per cent of total production cost. Therefore, by taking the mean, we assume that the service charge would increase production cost by 6per cent. It means that in our simulation whoever uses GM-soybean or GM-corn in processing, the costs of its intermediate inputs would increase by 6per cent.

Scenario 2 (S2): Mandatory labeling with consumers' rejection toward GM products.

Beside the traceable mandatory labeling policy, we further consider consumers preferences toward GM products. After the traceable mandatory labeling policy is practiced, consumers are able to differentiate the GM products from conventional food. We therefore assume that consumers would become sensitive in the use GM technology in food production. According to the survey notified by the Department of Health in September 2002, about 70per cent of Taiwan's consumers are aware of the existence of GM food. Among these 70per cent consumers, only 22per cent of them have bad impressions on GM food. Therefore, we assume that 15.4per cent (70per cent*22per cent=15.4per cent) of consumers are reluctant to consume GM products.

Scenario 3 (S3): Import ban on GM soybean and GM corn.

In this extreme case, we assume that Taiwan bans the import of GM soybean and GM corn. Technically, this is modeled as the import volumes of those GM crops drop to zero. Also, in this case there is no need to impose any labeling cost or extra charge to trace them. However, the domestic price of soybean and corn would be increased. This import-ban scenario would reflect the most extreme application of the precautionary principle within the framework of the Biosafety Protocol.

4. Empirical results

The results of macro impacts are shown in Table 2. The adoption of traceable mandatory labeling of GM soybean and GM corn will lower the real GDP by -0.013per cent, a very moderate drop. Overall price index would increase 0.014per cent. This is mainly due to the increased costs of intermediate inputs when labeling policy is put into practice. If we consider consumer preference change after the labeling policy is in effect, it would not have any impact on macro economic variables. It means that consumers' attitude change could not affect the macro economy. However, it could increase the utility level by 0.0243per cent on an individual basis. Last, if Taiwan government implements the GM crops import ban, there would be a higher negative shock on real GDP (-0.29 per cent). The overall price would increase 0.48per cent.

The effects on outputs produced by different sectors are shown in Table 3 for the first two scenarios. Comparing the results of S1 and S2, there are significant differences in bother GM and non-GM product sectors. For example, when traceable mandatory labeling policy is implemented, there is very little change in the output of GM processing foods. However, adding consumers' attitude change would decrease the output of GM processing food by 1.6 billion NT dollars. It also stimulates an increase in the output of non-GM processing food because consumers would now turn to consume more non-GM food.

Table 4 shows the impacts on prices, employment and import of different sectors of the first two scenarios. Again, we can see that if we consider consumers' attitude change, there would be more significant impact on sectoral prices and labor employment because the substitute effects between GM-variety and non-GM variety.

In the third scenario when Taiwan is engaged a ban on GM soybean and GM corn imports. Since Taiwan did not grow any GM crop, there would be no GM-contained product any more. Table 4 shows the output effects and price effects for this import ban policy. The output impacts are almost all negative across sectors, especially for livestock and the related processing sectors like oil and fat, animal feed. The total value of production would suffer a loss of 9.1 billion NT dollars. Prices for oil and fats and animal feeds would increase by 18.17per cent and 15.07per cent, respectively. Livestock price will also increase 4per cent. Therefore, imposing import ban will force consumers to suffer from higher food prices. It would also force domestic soybean and corn production to increase at the expense of other agricultural production. It could also worsen the overall resource allocation efficiency.

5. Concluding remarks

This paper investigates the impact of importing GM crops and related policy changes on Taiwan's economy and food sector. Under a general equilibrium context, we extend the existing model by distinguishing between GM and non-GM varieties as production inputs and as final consumption goods. We also endogenize consumers and producers choices in choosing between GM-contained and non-GM products so that consumers' concerns on food safety can be reflected into the policy simulations. The substitution of GM and non-GM foods is modeled by a CES function on the demand side, which then results in a ripple effect on domestic output on the supply side.

Our simulation results show that the traceable mandatory labeling of GM soybean and GM corn could only cause a slight decrease in domestic output. The real GDP would also be slightly decreased. However, when consumers are able to choose and reveal their reluctant to accept GM food under the mandatory labeling system, it would further induce the processors to decrease GM food production and transfer resources to produce non-GM foods. As a result, more significant changes in production and resource reallocations can be observed. Our result implies that although the social cost of a verifiable labeling system might not be too expensive to be a concern, the consumers' preference change might call for some serious structural realignment in Taiwan's agriculture and food processing industry. Policy makers should pay more attention to consumers' awareness and investigate the impact of how mandatory labeling policy would affect their consumption patterns.

If Taiwan imposes an import ban on GM crops, it would reduce real GDP and output of processing sectors and raise their prices in a substantial manner. This implies that the import ban would be a costly policy change for both producers and consumers in Taiwan.

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Table 1. Estimated shares of GM varieties in GM-potential food production

Sector	Sub-sectors	Shares (%)	Commodities contained in the Input-Output Table
Other crops	Domestic:		Crops excluding paddy rice
	GM bean	0.00	
	Non-GM bean	0.01	
	GM corn	0.00	
	Non-GM corn	34.48	
	Other crops	65.42	
	Imported:		
	GM bean	19.21	
	Non-GM bean	19.21	
	GM corn	12.05	
	Non-GM corn	28.13	
	Other crops	21.40	
Livestock	GM	31.82	Hogs, other livestock, Slaughtering and by-products
	Non-GM	68.18	
Edible oil and fat	GM	49.45	Edible oil and fat
	Non-GM	50.55	
Feed	GM	31.82	Feed
	Non-GM	68.18	
Processed food	GM	39.81	Flour; rice; Sugar; Canned food; Frozen food; Monosodium glutamate; Seasonings; Dairy products; Sugar confectionery and bakery products; Miscellaneous food products.
	Non-GM	60.19	

Source：Estimated from 1999 Taiwan IO tables with 596 sub-sectors.

Table 2. Macro economic impacts under different scenarios

unit: per cent

Macro Impact	Scenario 1	Scenario 2	Scenario 3
Nominal GDP	0.0006	-0.0026	0.1867
Real GDP	-0.0132	-0.0153	-0.2909
Price index	0.0138	0.0127	0.4776
CPI	0.0255	0.0209	0.5479
Export	-0.0235	-0.0211	-0.5123
Import	0.0015	0.0097	0.0572
Terms of Trade	-0.0121	-0.0127	0.1419
Utility per person	0.0000	0.0243	0.0000

Source: model simulations.

Table 3. Impacts on output by sectors

Unit: million NT$

	Original Output	Scenario 1		Scenario 2	
		Value change	per cent change	Value change	per cent change
Paddy Rice	44,390	-40	-0.09	-107	-0.24
GM-soybean	27	-3	-12.12	-1	-4.86
Non-GM soybean	37	1	1.67	1	1.49
GM-corn	14	-2	-12.39	-1	-4.84
Non-GM corn	3,588	10	0.29	1	0.02
Other crops	6,614	-3	-0.04	-25	-0.38
Special & horticultural crops	149,305	-30	-0.02	-724	-0.49
GM-livestock	100,877	-293	-0.29	-1,268	-1.26
Non-GM livestock	216,147	-151	-0.07	737	0.34
Agricultural services	49,296	-35	-0.07	-141	-0.29
Forestry	1,110	0	-0.01	0	-0.02
Fish	110,026	-33	-0.03	-26	-0.02
Energy & mineral products	95,779	-19	-0.02	-7	-0.01
GM-oil and fats	17,715	-285	-1.61	-379	-2.14
Non-GM oil and fats	21,374	56	0.26	94	0.44
GM-animal feeds	21,295	-258	-1.21	-273	-1.28
Non-GM animal feeds	45,629	141	0.31	142	0.31
GM-processing foods	119,700	-120	-0.10	-1,595	-1.33
Non-GM processing foods	183,132	-147	-0.08	919	0.50
Beverages and tobacco	141,219	-14	-0.01	44	0.03
Leather products	896,109	-269	-0.03	-143	-0.02
Lumber and by-products	477,457	-95	-0.02	-27	-0.01
Chemical industry	1,754,504	-351	-0.02	-261	-0.01
Other industry products	5,490,840	-549	-0.01	-533	-0.01
Transportation	2,969,566	-594	-0.02	-1,235	-0.04
Services	9,252,678	-925	-0.01	722	0.01
Total	22,166,208	-4,007		-4,090	

Source：model simulations

Table 4. Impacts of economic indicator of different sectors (S1 and S2)

Unit : per cent

	Price		Employment		Import	
	S1	S2	S1	S2	S1	S2
Paddy Rice	-0.028	-0.195	-0.116	-0.323	-0.065	-0.253
GM-soybean	10.796	10.872	-16.510	-6.624	-3.257	-3.023
Non-GM soybean	0.139	0.100	2.317	2.059	2.250	2.259
GM-corn	10.388	10.504	-16.399	-6.403	-4.302	-4.054
Non-GM corn	0.097	-0.093	0.407	0.028	1.046	1.063
Other crops	-0.020	-0.230	-0.061	-0.523	-0.323	-0.437
Special & horticultural crops	0.014	-0.160	-0.022	-0.597	-0.023	-0.438
GM-livestock	0.608	-0.254	-0.703	-3.045	0.278	-0.465
Non-GM livestock	0.230	0.533	-0.160	0.825	0.121	0.419
Agricultural services	-0.072	-0.361	-0.136	-0.552	0.000	0.000
Forestry	-0.045	-0.106	-0.045	-0.080	-0.021	-0.028
Fish	0.015	0.021	-0.072	-0.050	0.003	0.022
Energy & mineral products	0.005	0.010	-0.029	-0.011	-0.013	-0.007
GM-oil and fats	2.252	1.786	-4.492	-5.955	2.483	1.127
Non-GM oil and fats	0.197	0.324	0.720	1.217	0.580	0.998
GM-animal feeds	0.821	0.778	-2.504	-2.660	-0.898	-1.029
Non-GM animal feeds	0.733	0.711	0.643	0.645	0.572	0.584
GM-processing foods	0.137	-0.135	-0.142	-1.926	0.172	-1.766
Non-GM processing foods	0.114	0.163	-0.116	0.725	0.146	0.898
Beverages and tobacco	0.019	0.034	-0.012	0.073	0.037	0.103
Leather products	0.004	0.006	-0.042	-0.024	0.000	0.033
Lumber and by-products	0.008	0.010	-0.025	-0.008	-0.001	0.020
Chemical industry	0.003	0.003	-0.032	-0.027	-0.006	0.000
Other industry products	0.003	0.004	-0.027	-0.018	-0.006	0.005
Transportation	0.010	-0.007	-0.025	-0.062	0.009	0.005
Services	0.013	0.024	-0.012	0.013	0.021	0.063

Source：model simulations

Table 5. The Impact of import ban of GM soybean and GM corn (S3)

Unit : million NT$

	Original Output	Output		Price
		Value change	per cent Change	per cent Change
Paddy Rice	44,390	-1,010	-2.28	-0.76
Soybean	64	34	52.55	4.37
Corn	3,602	258	7.16	2.34
Other crops	6,614	-64	-0.97	-0.47
Special & horticultural crops	149,305	-632	-0.42	0.26
Livestock	317,025	-11,391	-3.59	4.15
Agricultural services	49,296	-773	-1.57	-1.62
Forestry	1,110	-2	-0.22	-0.98
Fish	110,026	-1,075	-0.98	0.43
Energy & mineral products	95,779	-393	-0.41	0.10
Oil and fats	39,089	-6,885	-17.61	18.17
Animal feeds	66,924	-9,713	-14.51	15.07
Processing foods	302,832	-3,673	-1.21	1.77
Beverages and tobacco	141,219	-181	-0.13	0.42
Leather products	896,109	-5,292	-0.59	0.09
Lumber and by-products	477,457	-1,763	-0.37	0.17
Chemical industry	1,754,504	-6,643	-0.38	0.06
Other industry products	5,490,840	-17,466	-0.32	0.06
Transportation	2,969,566	-10,747	-0.36	0.20
Services	9,252,678	-13,888	-0.15	0.28
Total	22,166,208	-91,295		

Source：model simulations

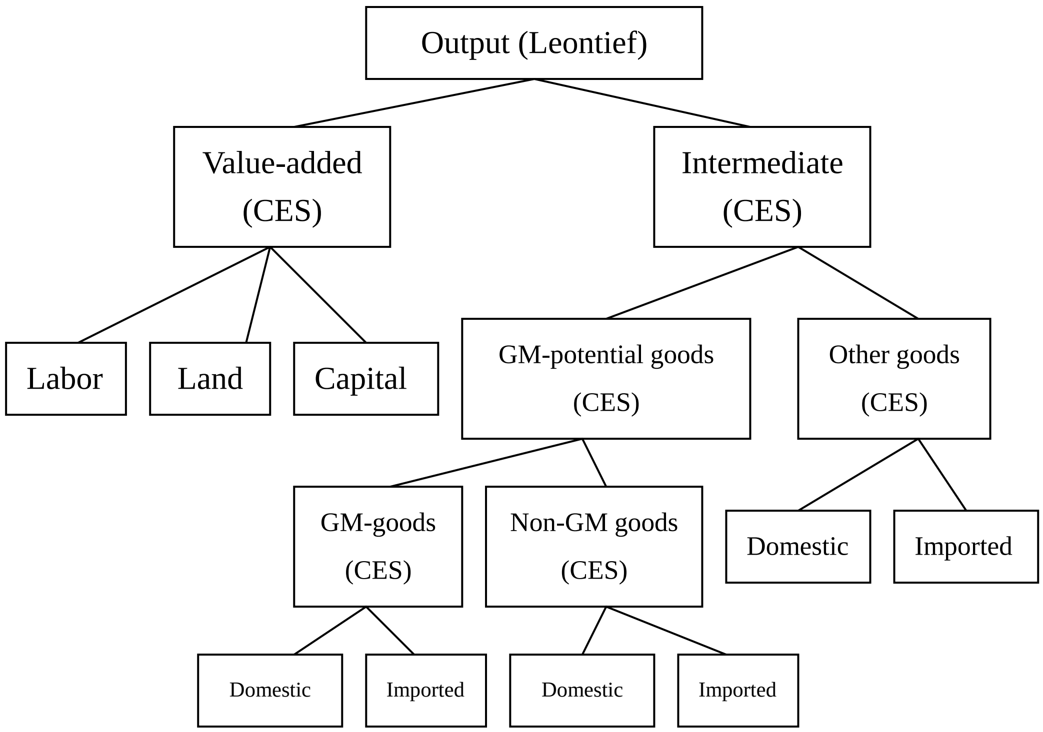

Figure 1. GM vs. non-GM choice in intermediate demand

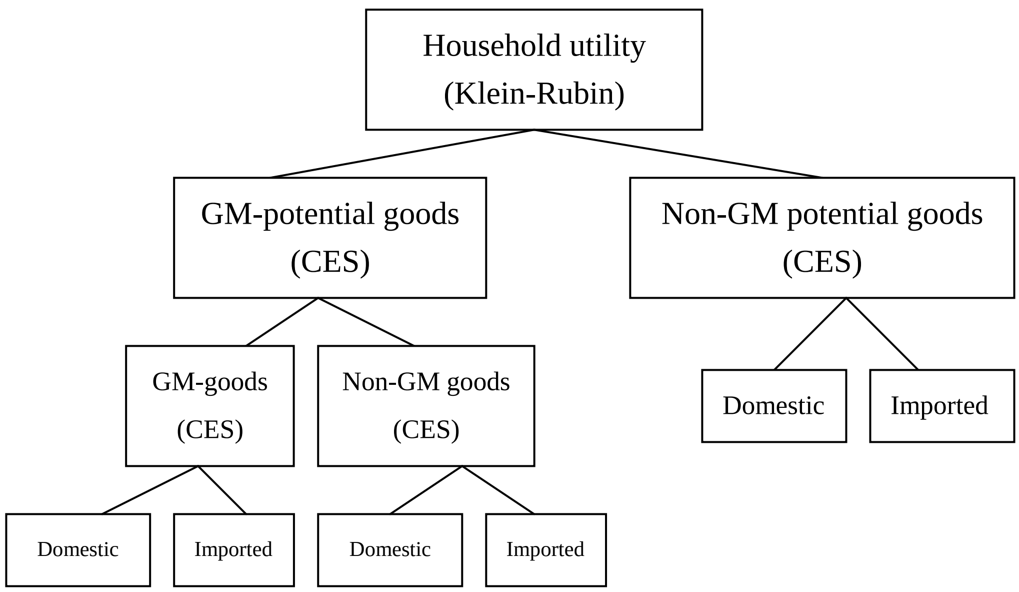

Figure 2. GM vs. non-GM choice in final demand