The Economic Analysis of GM Crops impacts on Taiwan's Agriculture

By

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Abstract

This paper offers a preliminary quantitative assessment of the economic impacts of Taiwan importing GM crops on agricultural sector. For this purpose, a multi-sectoral computable general equilibrium model is used, named TAIwan General Equilibrium Model (TAIGEM). This model is amended by splitting the corn and soybeans into GM and non-GM varieties, and endogenizes the decision of producers and consumers to use GM vs. non-GM corn and soybeans in their intermediate use and consumption, respectively. The GM crops is assumed to have higher factor productivity as compared with conventional crops, then we also concern about the consumers' acceptance of GM food product and its implication for the labeling policy. This study will focus on the Taiwan agricultural economic aspects of these GM policy issues.

Key words: General Equilibrium Model, Genetically Modified Organisms (GMOs), Agricultural, Corn and Soybeans.

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1. Introduction

The new agricultural biotechnologies that are generating transgenic or genetically modified organisms (GMOs) are getting more and more concern. Among all major agricultural technology innovations, biotechnology is by all means the most controversial due to in part of the prevailing uncertainty and concerns raised by many for its biosafety and environmental impacts. The rise of modern biotechnologies and life science are bringing with them many surprises and may change the paradigms of the society and revolutionize our daily lives (Ku, 2002). Against the many successful examples of biotechnology, it is very important to bear in mind that all technologies, bio and non-bio, are to serve the ultimate objective of improving the overall welfare of human beings and the nature. Agricultural biotechnology has no exception. Furthermore, agriculture is the foundation of people's livelihood.

Although until now , Taiwan haven't commercialize any GM foods, but Taiwan used to highly dependent on importing lots of grain products from world market, and the import quantity as well as price will be affected through world market as the production technology of GM crops is adopted. When the GM crops were imported to Taiwan, as suppliers of inputs and buyers agricultural products, other sectors will also be affected by the use of genetic engineering crops through vertical (or backward) and horizontal (or forward) linkages.

Since Taiwan consumers have hardly any data upon which to base their choices, this paper would offer a preliminary quantitative assessment of the economic impacts of Taiwan importing GM crops (say soybeans and corn) on agricultural sector. For this purpose, a multi-sectoral computable general equilibrium model is used, named TAIwan General Equilibrium Model (TAIGEM). This model is amended by splitting the soybeans and corn into GM and non-GM varieties, and endogenizes the decision of producers and consumers to use GM vs. non-GM corn and soybeans in their intermediate use and consumption, respectively. The GM crops is assumed to have higher factor productivity as compared with conventional crops, then we also concern about the consumers' acceptance of GM food product and its implication for the labeling policy. This study will focus on the Taiwan agricultural economic aspects of these GM policy issues.

2. GM corn and soybeans trade in Taiwan

Soybean and corn are not the main crops planted in Taiwan, we used to importing those crops for consuming and processing. So before discussing the GM soybeans and corn in Taiwan, we should see the trade about GM soybean and corn first.

2.1 The Trade of GM soybean and corn

There were virtually no GM crops on the field before the 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% increase. Between 1996 and 2001, the total area of GM crops grew about 30 times. Production of GM crops is currently concentrated in just a few countries while more countries are experimenting new traits. For 2001, 99% of GM crops are produced in four countries, namely US (68%), Argentina (11.8%), Canada (6%) and China (3%). In crop-wise, the first is GM soybean, about 63% of global area, and GM corn next, accounts for 19%(ISAAA, 2002). The same report also indicated that the two major GMO traits in 2001 were herbicide tolerant crops, accounted for 77% of all GM crops, while Bt maize accounted for 11%.

In terms of trade, it is obvious that the world's top three GM crop producing countries are all major agriculture exporters, for example, U.S., Canada and Argentina. China's is growing very fast in GM products but mostly for domestic consumption (Huang et al, 2002). The majority of GM agricultural products in trade concentrates in crops. This section will attempt to estimate the global trade volume using data available from various sources using GM soybean and GM corn ,the two leading GM crops as examples.

Although the estimated global planting acreage of GM crops is around 52.6 million hectares as stated previously in this paper, there is yet no available statistics on the amount of the global GM product in trade. However, it is possible to estimate the trade volume of GM products with information available from various sources. A compilation of data is presented as follows.

Trade volume of GM products can be estimated from both the production side and the demand side. Existing data are available for total production and planting acreage of major GM crop producers but trade statistics do not distinguish export of GM from non-GM products. Under such circumstances, unit difference between GM and non-GM in terms of yield must be utilized in the estimation of GM crop trade. This, however, requires elaboration. Yield is a function of many variables. According to Rice and Pilcher (1998 cited in Fernandez-Cornejo and McBride, (2002)), returns to Bt corn is a function of expected corn yield, the number of pest per plant, and the effectiveness of pest control. Shoemaker (2001) also reports that benefits and performance of GM crops are influenced by factors such as location, pest infestation level, seed and technology costs, irrigation and others. Survey of the literature indicates that the yield of GM and non-GM crops differ greatly from crop to crop (Fernandez-Cornejo and McBride, 2002; Hategekimana, 2002; Carpenter, 2001; Shoemaker, 2001). As revealed by these reports, the variation of unit crop yield ranged from 20% increase to yield loss. For consistency, this study will adopt the recent statistics given the criterion of sufficient representation. Simple mathematical average will be taken when data from various sources support different results.

2.1.2 *GM Soybean*

World's top three GM crop growing countries exhibit similar trade patterns in terms of soybean. U.S. exports about 36% of its soybean production, followed by Canada exports 33% and Argentina exports 27% (compiled from USDA, 2002). The 2000/2001 global trade volume of soybean estimated 54.88 million metric tons (mt) and top three exporters were U.S. (49.4%), Brazil (27.5%), and Argentina (13%) (USDA, 2002). ISAAA (2002) data indicated that, for 2001, GM soybean made up 46% of global soybean planting area. 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 findings of a Canadian study, Hategekimana (2002) reported that preliminary results showed that GM soybean had a productivity about 3% to 4% higher than conventional soybean. Shoemaker (2001) on the other hand, reported a yield difference between 1% and 5%. With this information, the simple mathematical average of 4% is therefore used to calculate the shares of GM and non-GM soybeans of the global production. As estimated by this study, for 2001, GM and non-GM soybeans production were about 84 million mt and 92 million mt, respectively. The ratio of tonnage between GM and non-GM soybeans is therefore 47.5% to 52.5%. This estimate is slightly higher than ISAAA's 2002 figure of 46%.

Assuming that GM and non-GM soybeans have an equal probability of being exported, the trade volume of GM soybean can be approximated. Once again, using USDA (2002) statistics, the global soybean trade amounted to 54.88 million mt in 2001. If we accept the assumption of equally probability of export, then the estimated global GM soybean trade volume of 26 million mt can be obtained. In percentage, 47.5% of soybean globally traded is genetically modified. Among major soybean exporting countries, Argentina is worth noticing. After taking the productivity factor into account, over 98% of soybean harvested was GM. Consequently, Argentina exported about 13% of the global soybean trade volume. As for the world's largest soybean exporter U.S., NASS (2002) reported a GM share of 74 percent in acreage, which can be converted into 77% of production. Again, assuming equal probability of export, an estimate of GM soybean exports around 21 million mt can be calculated. U.S. and Argentina GM soybean together accounts for roughly half of global soybean trade volume.

2.1.3 *GM Corn*

In the case of corn, productivity varies greatly. Hategekimana (2002) reported a range between 4% and 12% higher than traditional corn production. Monsanto (2002) reported a 13.1 bushels per acre increase. Compared the 13.1 bushels increase to the 119 bushels per acre average between 1990 and 1995 (Dittrich, 2002), the last five years before GM corn planted in large scale, this may translate into a roughly 11% increase. Taking the simple mathematical average of these reports, a 9.5% yield increase is used in the calculation of estimated trade volume.

ISAAA (2002) reported that biotechnology varieties made up 19% of global corn planting area and USDA (2002) statistics indicated a global production of 585.69 million tons. With the difference in unit yield, it can be estimated that total world production can be divided into to a GM portion of 20% and a non-GM portion of 80%, which translates into around 117 million mt of GM corn and 469 million mt of non-GM corn, respectively.

World's top three corn exporters of 2000/2001 were U.S. (64%), Argentina (15%) and China (9.6%) (Compiled from USDA, 2002). Although trade data on Chinese corn is not available, Monsanto (2001) reported that 13% of total cornfields in Argentina uses Monsanto technology, which converts to 14.2% total production. Again, assuming GM and non-GM corn are equally possible to be exported, this number suggests that at least 1.7 million mt of GM corn are exported by Argentina. U.S. farmers planted 26% of cornfield with GM varieties in 2001 (NASS, 2002), doubling that of Argentina. Using the same calculation, it can be estimated that around 28% of U.S. corn export is GM products. In absolute terms, that is 14 million mt.

2.2 Taiwan's GM foods

Until today although Taiwan hasn't produced any GM soybean or GM corn, but Taiwan used to importing lots of grains for consumption directly or for processing use. According to the latest issue (1999) Input-Output Table published by Directorate General of Budget Accounting and Statistics Executive Yuan. R.O.C., the total domestic output value of Taiwan's soybean was 9 million N.T. dollars; all of them are non-GM products. The same year Taiwan imported 16.8 billion N.T. dollars of soybean from abroad, and considering the estimation of GM soybean trade proportion in the above context, there are about 52.5% belong GM soybeans and 47.5% belong non-GM soybeans.

Then we see the corn in Taiwan, the domestic output value in 1999 is 3 billion N.T. dollars, and the same, there are all non-GM corn. In importing part, the imported value of Taiwan's corn is 17.2 billion dollars, among them 24.14% belong GM corn and 75.86% belong non-GM corn.

The soybean and corn except for directly consumption, the greater part of them will flow into other departments to be the process material. They would be used in animal feeds; oil and fats; dairy products or process foods. Information on any number of the attributes of GM food product can be recorded and passed along the food marketing chain. GM foods nowadays are coming onto the market, and over the past year, food biotechnology has received increased attention in Taiwan.

2.3 Taiwan's Policy for GM foods

In Taiwan, government has put the priority on maximizing the impact of the new agro-biotechnology at the farm level. Public awareness, food safety and intellectual property rights are equally respected and knowledge of basic research on agro-biotechnology is considered an issue of the public domain. In this regard, the government takes the initiative in research and development of biotechnology. Findings with potential for further applications are transfer to the private sectors and farmers through various extension channels. So far, research findings on biotechnology by the public sector, particularly the agricultural research institutes, have been applied to agricultural production such as tissue culture, healthy seedling, breeding improvement, biopesticides, biofertilizers, vaccines and etc. Banana, citrus, horticulture, ornamentals, and aquaculture have benefited greatly.

At present, policies on GM food labelling vary in different countries and areas: In Taiwan, voluntary labeling of GM food has been introduced by Department of Health in Taiwan from 1 January 2001, while mandatory labeling of designated foods will be introduced in three stages according to degree of processing of the food products starting from January 2003. Under the new labeling requirement, foods containing GM soybean or corn that are more than 5% total weight of the finished product has to be labeled. Moreover, GM soybean or corn containing not more than 5% GM materials is regarded as "non-GM ingredient". On the other hand, Taiwan only designated food items that contain GM ingredients as major components are needed to be labeled.

3. TAIGEM Model and Scenarios

TAIGEM model is a multisectoral, computable general equilibrium (CGE) model of the Taiwan's economy derived from ORANI model (Dixon, Parmenter, Sutton and Vincent, 1982). The input-output database was compiled from the 160-sector Use Table of the 1999 Taiwan's Input-Output tables. TAIGEM model distinguishes 160 sectors, 6 types of labor, 8 types of margins and 160 commodities. Like ORANI model, TAIGEM model was designed for comparative-statics mechanism, i.e., for projecting what difference a shock would make to the economy at a point in time.

3.1 TAIGEM Model's Production Structure:

TAIGEM model allows each industry to produce several commodities, using as inputs domestic and imported commodities, labor of several types, land, capital, energy of several types and "other costs". In addition, commodities destined for export are distinguished from those for local use. The multi-input, multi-output production specification is kept manageable by a series of separability assumptions, illustrated by the nesting shown in Figure 1 which shows the production structure of TAIGEM model.

Profit-maximization 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. Assuming cost minimization and technology constraint at each level of production, producers will make optimal input demand decisions. At the third level, commodity composites and a primary-factor composite are combined using a Leontief production function. Consequently, they are all demanded in direct proportion to the industry activity. At the fifth level, each commodity composite is a CES (constant elasticity of substitution) function of domestic goods and the imported equivalent (the Armington assumption). At the forth level, the primary-factor composite is a CRESH[1] aggregation of labor, land, and capital. And at the fifth level, the labor composite is also a CRESH aggregation of different occupations; At the bottom level the products composite is a CES aggregation of domestic goods and imported goods.

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[1] CRESH (Constant Ratios of Elasticities of Substitution, Homothetic) function is the generalized form of CES function, the functional form is $\sum_{i=1}^{n}\left[\frac{X_i}{Z}\right]^{h_i}\frac{Q_i}{h_i}=\alpha$, where Z is output level, X_i are factor inputs, Q_i, h_i and α are parameters, $0\neq h_i<1$, $Q_i>0$, and $\sum_{i=1}^{n}Q_i=1$. IF $h_i=h$, then CRESH functional form is reduced to the CES (Constant Elasticity of Substitution) function. The primal distinction between CRESH function and CES function is that the substitution elasticity of factors are equal to some constant in CES function, but in CRESH function the substitution elasticity of one pair of factors may be different from that of another pair of factors. For details about CRESH function, see Hanoch (1971).

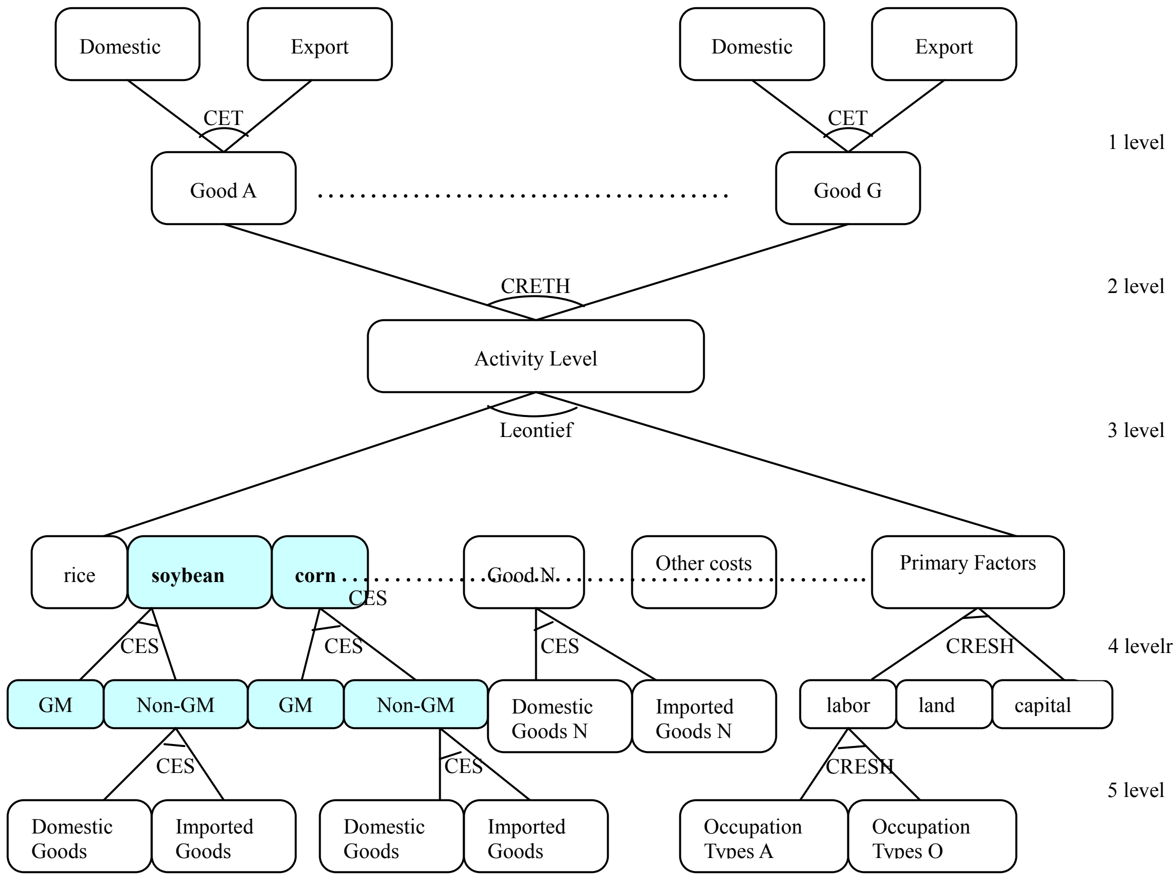

Figure 1 Structure of Production of TAIGEM

Like ORANI model, the output structure of TAIGEM model allows for each industry to produce a mixture of all the commodities. Moreover, conversion of an undifferentiated commodity into goods destined for export and local use is governed by a CET (constant elasticity of transformation) transformation frontier.

3.2 TAIGEM Model's Household and other final demands' Structure:

TAIGEM model assume that the utility function takes the nested form. Household as the price taker and maximize their utility function subject to budget constrain. The form of the household's utility is Klein-Rubin function, also known as LES (Linear Expenditure System) function. In the LES function, there is substitution between different goods, and the goods are composted a CES aggregation of domestic goods and imported goods. Figure 2 shows the household demand function structure of TAIGEM model.

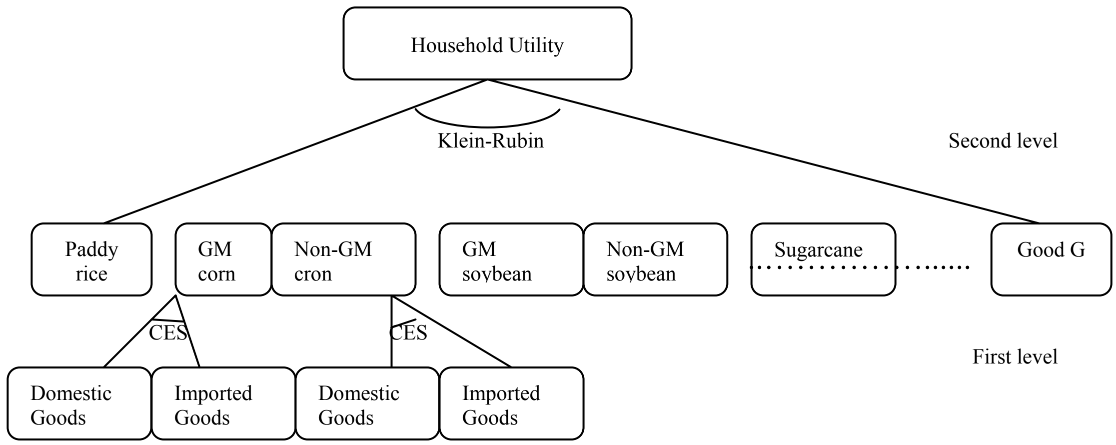

Figure 2 Structure of Household of TAIGEM

3. 3 Sector classification

TAIGEM model used in this research is divided for 40 sectors; including 14 of primary agriculture sectors: paddy rice; corn; soybean; other common crops; sugarcane; other special crops; fruits; vegetables; other horticultural crops; hogs; other livestock; agricultural services; forestry; fish; 16 of food processing sectors: slaughtering and by-products; edible oil and fat by-products; flour; rice; sugar; animal feeds; canned foods; frozen foods; monosodium glutamate; seasonings; dairy products; sugar confectionery and bakery products; food products; non-alcoholic beverages; alcoholic beverages; tobacco. And remaining 10 non-agricultural sectors: Minerals; leather products; Lumber and by-products; chemical industry; chemical fertilizers; medicine; plastic products; other industry products; transportation; and services.

Besides above classifications, this model is also amended by splitting the soybeans and corn into GM and non-GM varieties, and endogenizes the decision of producers and consumers to use GM vs. non-GM corn and soybeans in their intermediate use and consumption, respectively. Then in order to discriminate consumer's choice respond to GM food, we further splitting the oil and fats into GM and non-GM varieties, too.

3.4 Design of experiments:

The quantitative analyses described here all make used of TAIGEM model and are based on the Input-Output Table published by Directorate General of Budget Accounting and Statistics Executive Yuan. R.O.C. In order to appreciate the relative importance of these primary agricultural sectors and their related processing sectors to the economies, note from Table 1 shows that share of GM-potential by soybean and corn, then the GM-contains would get into other sectors or food processing sectors, like feeds, diary products, and lots of parts to oil and fats sectors. According to our calculation, the share of oil and fats use GM-soybean and GM-corn is 19.47%.

In the base data for this model analysis, the structures of production in terms of the composition of intermediate input and factor use in the GM and non-GM varieties are initially assumed to be identical. And the decision of producers and consumers to use GM or non-GM varieties in production and final demand are endogenized. Intermediate demands for each composite crop (i.e. GM and non-GM) are fixed as proportions of outputs. Similarly, final consumption of each composite GM-potential good is also endogenous choice between GM and non-GM varieties. The choice between GM and non-GM varieties is determined by a LES function.

Table 1 Share of GM-potential in Taiwan's crop and processing food.

Commodities	Share of GM-potential
Soybean	
Domestic goods	0%
Imported goods	52.5%
Corn	
Domestic goods	0%
Imported goods	28.0%
Oil and Fats	19.47%

4. Results of Empirical Analysis

This paper provides some scenarios to simulate the impacts of GM products in Taiwan, now describe as follows:

Scenario 1：The price of GM crops (soybean and corn) decrease.

Supposing that the imported price of Taiwan's GM soybean and corn will decrease 15% due to the GM technology improvement and increase the GM crops' yield.

Scenario 2□Scenarios 1 with consumers' preferences change to against GM products.

Supposing that GM soybean and corn's imported price decrease 15% and Household expenditure elasticity to GM soybean and GM corn decrease (from 0.18 to 0.01), and also the taste of household import/domestic composite toward GM products change.

Table 2 shows the results of 2 TAIGEM scenarios above, suppose that imported price of Taiwan's GM soybean and corn decrease 15% due to the GM technology improvement and increase the GM crops' yield. The result shows that almost each agricultural sectors and processing food sectors' output will increase (expect for forestry), especially for oil and fats sector (increase about 0.39%). And the animal feeds sector's output will be increase by 0.085%.

Then we see the effects of output price, great part of the agricultural sectors and processing food sectors' output price decrease, especially for GM-oil and fats (decrease about -8.29%). Follow the animal feeds' output price decrease -0.49%. Table 1 also shows the influence of agricultural employment, since the output increase, it will be related increasing the employment.

In scenario 2, assuming that consumers' preference change to against GM products, we can compare with scenario 1, and see the results are similar in Non-GM sectors, but will affect the GM sectors, like oil and fats. Due to consumers do not like GM products, the output of GM oil and fats will decrease 0.91%, and the output price decrease by 8.69%. The effect of employ by GM oil and fats sector will reduce form 1.04% to -2.35%.

Table 2 Scenario 1 (S1) and scenario 2 (S2)□Effects of imported price decrease and preference change Unit□%

Sector \ Scenario	*Output*		*Output price*		*employ*	
	S1	S2	S1	S2	S1	S2
Other Crops	0.021	0.021	0.006	0.007	0.028	0.029
GM corn	-26.271	-34.767	-0.257	-0.308	-32.708	-42.093
Non-GM corn	0.175	0.175	0.053	0.054	0.239	0.239
GM bean	-27.392	-37.034	-0.154	-0.178	-33.977	-44.509

Non-GM bean	3.452	3.453	0.084	0.084	4.769	4.770
Sugar Cane	0.020	0.021	0.002	0.002	0.024	0.026
Special Crops	0.031	0.029	0.005	0.004	0.040	0.038
Fruits	0.003	0.004	-0.006	-0.006	0.004	0.005
Vegetable	0.008	0.008	-0.004	-0.003	0.011	0.011
Horticultural	0.004	0.004	-0.007	-0.007	0.004	0.005
Hogs	0.065	0.066	-0.144	-0.144	0.198	0.202
Other livestock	0.049	0.051	-0.160	-0.161	0.099	0.102
Agricultural service	0.022	0.023	0.020	0.021	0.042	0.043
Forestry	-0.014	-0.011	-0.014	-0.012	-0.016	-0.013
Fish	0.021	0.021	-0.008	-0.008	0.043	0.044
Slaughter	0.046	0.047	-0.101	-0.101	0.091	0.093
GM oil and fats	0.394	-0.912	-8.291	-8.696	1.037	-2.354
Non-GM oil and fats	0.262	0.270	0.158	0.163	0.689	0.710
Flour	0.037	0.037	-0.011	-0.010	0.065	0.067
Sugar	0.019	0.020	-0.006	-0.006	0.012	0.013
Animal Feed	0.085	0.087	-0.488	-0.490	0.171	0.173
Can Food	0.014	0.015	-0.013	-0.013	0.020	0.021
Frozen Food	0.085	0.085	-0.042	-0.042	0.148	0.149
Monosodium glutamate	0.011	0.011	-0.003	-0.002	0.017	0.017
Seasoning	0.047	0.047	-0.040	-0.039	0.068	0.069
Dairy product	0.049	0.051	-0.057	-0.058	0.072	0.074
Bakery product	0.018	0.019	-0.021	-0.021	0.026	0.028
Food product	0.053	0.054	-0.057	-0.057	0.067	0.068
Non-alcoholic beverage	0.000	0.001	-0.005	-0.005	0.000	0.002
Aalcoholic beverage	0.002	0.002	-0.006	-0.005	0.004	0.006
Tobacco	0.002	0.003	-0.005	-0.004	0.006	0.007

Source：simulation result

Now we discuss the economic effects about mandatory labeling policy for GM products. Here are 3 different scenarios:

Scenario 3：Mandatory labeling policy

Consulting the European Commission (2000) estimated the overall costs for current GM labeling program to increase the cost of grain by 6-17%, so we assume labeling policy cause production costs increased. Set the other cost of both GM and non-GM oil and fats increase 15%.

Scenario 4：Scenario 3 with consumers' preferences change to against GM products

Base senario3 and assume household expenditure elasticity to GM oil and fats decrease (from 0.85 to 0.01), and the taste of household import/domestic composite toward GM oil and fats change.

Scenario 5：Scenario 3 with price divergence between GM and Non-GM products

Base senario3 and assume that labeling policy will cause the price of GM products decrease (-15%), while non-GM products' price maintain the same level.

Table 3 shows the results of S3-S5 scenarios above, suppose that mandatory labeling policy will cause production costs increased 15%, there is just a little influence to different sectors. The output of GM oil and fats; non-GM oil and fats; animal feeds; frozen food; diary products are decrease about 0.002%. Output price of GM and non-GM oil and fats' sector increase 0.026% and 0.061%, and the employ decrease 0.07% .Then when consider about consumers' preference change to against GM products. Consumers do not like GM products any more. The output of GM oil and fats will decrease 4.67%, and the output price decrease by 1.28%. The effect of employ by GM oil and fats sector decrease 11.36%.

Senario5 assume that labeling policy will cause the price of GM products decreasing, while non-GM products' price maintains the same level. So consumers would be preferred to buy more GM products from abroad, and reduce domestically productions. The economic effects about output of GM oil and fats will decrease 4.53%, and the output price decrease by 9.7%. The effect of employ by GM oil and fats sector decrease 11.06%.

Table 3 Scenario 3 – 5 (S3-S5)：Effects of labeling policy for GM products

Unit：%

Sector \ Scenario	output			Output price			employ		
	S3	S4	S5	S3	S4	S5	S3	S4	S5
Other Crops	0.000	0.002	0.023	0.000	0.002	0.005	-0.001	0.003	0.031
GM corn	0.000	0.003	-26.270	0.000	0.000	-0.257	0.000	0.004	-32.707
Non-GM corn	0.000	0.003	0.176	0.000	0.002	0.052	0.000	0.003	0.241
GM bean	0.000	0.004	-27.392	0.000	0.000	-0.154	0.000	0.005	-33.977
Non-GM bean	-0.001	0.002	3.455	0.000	0.000	0.083	-0.001	0.003	4.773
Sugar Cane	-0.001	0.003	0.024	0.000	0.002	0.001	-0.001	0.003	0.030
Special Crops	-0.001	-0.009	0.025	0.000	-0.002	0.001	-0.002	-0.011	0.033
Fruits	0.000	0.003	0.004	0.000	0.001	-0.008	0.000	0.003	0.005
Vegetable	0.000	0.003	0.009	0.000	0.002	-0.006	0.000	0.004	0.012
Horticultural	0.000	0.003	0.004	0.000	0.002	-0.009	0.000	0.003	0.005
Hogs	-0.001	0.003	0.068	0.003	0.001	-0.152	-0.004	0.008	0.207
Other livestock	-0.001	0.003	0.052	0.005	-0.001	-0.169	-0.003	0.006	0.105
Agricultural service	-0.001	0.002	0.023	0.000	0.003	0.020	-0.001	0.004	0.044
Forestry	0.001	0.004	-0.013	0.001	0.002	-0.015	0.001	0.004	-0.015
Fish	0.000	0.000	0.023	0.000	0.001	-0.009	-0.001	0.001	0.047
Slaughter	-0.001	0.002	0.048	0.002	0.001	-0.107	-0.002	0.005	0.095
GM oil and fats	-0.026	-4.668	-4.533	0.026	-1.283	-9.699	-0.069	-11.365	-11.059
Non-GM oil and fats	-0.027	-0.001	0.342	0.061	0.074	0.213	-0.070	-0.003	0.902
Flour	-0.001	0.002	0.042	0.000	0.001	-0.010	-0.001	0.004	0.074
Sugar	-0.001	0.003	0.024	0.000	0.001	-0.008	0.000	0.002	0.015
Animal Feed	-0.002	0.003	0.089	0.006	-0.003	-0.508	-0.003	0.006	0.179
Can Food	0.000	0.002	0.015	0.000	0.001	-0.015	-0.001	0.003	0.022
Frozen Food	-0.002	0.001	0.090	0.001	0.001	-0.045	-0.003	0.002	0.157
Monosodium glutamate	-0.001	0.000	0.023	0.000	0.000	-0.006	-0.001	0.000	0.036
Seasoning	-0.001	0.002	0.049	0.000	0.001	-0.041	-0.001	0.003	0.072
Dairy product	-0.002	0.003	0.053	0.002	0.000	-0.062	-0.002	0.005	0.077
Bakery product	-0.001	0.003	0.035	0.001	0.000	-0.041	-0.002	0.004	0.051
Food product	-0.001	0.003	0.059	0.001	0.000	-0.063	-0.001	0.003	0.074
Non-alcoholic beverage	0.000	0.003	0.000	0.000	0.001	-0.006	0.000	0.005	0.001
Aalcoholic beverage	0.000	0.002	0.002	0.000	0.002	-0.007	0.000	0.004	0.005
Tobacco	0.000	0.002	0.003	0.000	0.002	-0.006	0.000	0.004	0.007

Source：simulation result

As in the TAIGEM scenarios, the more-effective GM production process will initially cause labor, land, and capital to leave the GM sectors because lower GM product prices will result in lower returns to factors of production. To the extent that demand (domestically or abroad) is very responsive to this price reduction, this cost-reducing technology may potentially lead to increased production and hence higher returns to factors.

To the extent that the production of GM crops increases, the demand for inputs by producers of those crops may rise. Demanders of primary agricultural products, e.g. livestock producers using grains for livestock feed, will benefit from lower prices, which in turn will affect the market competitiveness of these ectors.

The other sectors of the economy may also be affected through horizontal (or forward) linkages. Primary crops and livestock are typically complementary in food processing. Cheaper genetically modified crops have the potential of initiating an expansion of food production and there may also be substitution effects. To the extent that substitutions in production are possible, the food processing industry may shift to the cheaper GM intermediate inputs. Widespread use of GM products can furthermore be expected to affect the price and allocation of GM factors of production and in this way also affect the other sectors of the economy.

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