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Does Biotech Labeling Affect Consumers' Purchasing Decisions? A Case Study of Vegetable Oils in Nanjing, China

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This study analyzes whether biotech labeling has an impact on consumers' purchasing behavior in China using vegetable oils in Nanjing as a case study. An Almost Ideal Demand System (AIDS), which encompasses expenditure shares of individual edible oils, is developed and estimated by seemingly unrelated regression with theoretical constraints. The AIDS model is augmented by the top-level demand for all edible oils in the context of a two-stage budgeting approach. Results from the model based on retail scanning data suggest that biotech labeling induced only a modest switch in vegetable oils consumption away from labeled soybean and blended oils and toward non-biotech vegetable oils.

Key words: biotech labeling, China, Almost Ideal Demand System, vegetable oils.

On January 5, 2002, China's Ministry of Agriculture (MOA) issued three ministerial decrees that set forth guidelines for biosafety regulation in China. Decree No. Ten, which addresses measures for agricultural biotech labeling, has the potential to influence public opinion, thereby affecting consumption of domestic and imported biotech products, such as herbicide-tolerant soybeans from the United States (Marchant, Fang, & Song, 2003).

In addition to requiring product safety reviews, China's biotechnology regulations require both domestically produced and imported biotech products to be labeled. Proponents of mandatory labeling generally credit it as a means of differentiating biotech from non-biotech food. Survey-based studies indicate that consumers in China overwhelmingly favor mandatory biotech labeling. For example, a survey conducted in 2002 of Nanjing consumers shows that approximately 95% of the respondents indicated that they favor mandatory biotech labeling, regardless of whether they were willing to buy biotech foods or not (Zhong, Marchant, Ding, & Lu, 2002). If labeling is merely a mechanism to differentiate biotech from non-biotech foods, Zhong et al. (2002) believe that it may not actually change consumers' attitudes toward biotech foods because virtually all respondents believed that labels should be required.

Serious questions have been raised as to the effectiveness of mandatory labeling in addressing asymmetric information about biotech content in food products between buyers and sellers, and externality problems stemming from the introduction of biotechnology (Golan, Kuchler, & Mitchell, 2000). While mandatory labeling for biotech content is informative to some consumers, it can also lead to greater confusion while reducing economic efficiency (Shoemaker, Johnson, & Golan, 2003). An alternative to mandatory labeling is a voluntary labeling system in which product information is conveyed to consumers who prefer to purchase only non-biotech products. Further, critics of mandatory labeling believe that labeling policies such as those adopted by the EU and Japan have created the misconception that biotechnology products are somehow less safe, despite their having been successfully assessed through a government review process. This misconception leads to the choice by manufacturers and retailers to use non-biotech ingredients in their processed food products. The policies promote a practice that, in effect, becomes a trade barrier to commodities that serve as ingredients in processed products.

However, whether mandatory labeling acts as a trade barrier to biotech ingredients hinges on the impact of biotech labeling on consumers' purchasing behavior. Accordingly, the main purpose of this paper is to investigate whether biotech labeling has an impact on consumers' purchasing behavior in China using vegetable oils in Nanjing as a case study. A central question to be addressed is: Does biotech labeling induce a switch in Chinese consumers' purchasing behavior away from labeled soybean and blended oils and toward non-biotech vegetable oils, such as sunflower and peanut oils?

We developed a flexible demand system to measure Chinese urban consumers' response to factors affecting consumers' purchasing decisions of vegetable oils, including vegetable oil prices, household budget, and other relevant variables. We also used cross-price demand elasticity to verify the likely magnitude of the impact of biotech labeling on consumers' purchasing decisions. The larger the cross-price elasticity of demand between two vegetable oils, the closer were the two products as substitutes in the eyes of consumers and thereby the larger the potential impact of biotech labeling on consumers' purchasing decisions.

This study is unique in that it makes use of retail scanning data of edible oils at five stores sampled from more than 100 outlets in Nanjing of a large supermarket company, which is a leading retail chain in China. In contrast, virtually all previous studies of consumer attitudes toward biotech foods, labeling, and willingness to pay in China and other countries, such as Zhong et al. (2002), Bai (2003), Asian Food Information Center (AFIC, 2004), International Food Information Council (IFIC, 2004), Chern, Rickertsen, Tsuboi, and Fu (2003), Li, Curtis, McCluskey, and Wahl (2003), Ding (2004), Lin, Somwaru, Tuan, Huang, and Bai (2006a), and Lin et al. (2006b), are based on surveys of consumers. These earlier survey studies indicate consumers' perception of biotech foods or willingness to purchase them if made available at specific reduced prices, rather than what consumers *actually* purchase. What is perceived by survey respondents may not always be consistent with their purchasing actions. In addition, survey respondents tend to overstate the amount they are willing to pay for quality enhancement of a private good, leading to the use of "cheap talk" to reduce the hypothetical bias inherent in the contingent valuation method (Lusk, 2003).

This study contributes to the literature by using *actual* purchasing data at supermarket outlets in Nanjing, China to determine if biotech food labeling has an impact on consumers' purchasing behavior of vegetable oils. To our knowledge, this study is one of the first studies in addressing the impact of biotech labeling on consumer behavior using actual purchasing data.[1]

China's Biotech Labeling

Following the practices of the European Union (EU), Japan, and other countries, China has established a policy that requires labeling of food products with biotech content. China bases this regulation in part to protect consumers' right to know information about food products. Seventeen commodities in five categories governed by the labeling regulations include: (1) soybean seed for planting, soybeans, soybean flour, soybean oil, and soybean meal; (2) corn seed for planting, corn, corn oil, and corn flour; (3) rape seed for planting, rapeseeds, rapeseed oil, and rapeseed meal; (4) cotton seed for planting; and (5) tomato seed for planting, fresh tomatoes, and tomato jam or sauce. All soybean oil made from biotech soybeans or blended oil that contains biotech soybeans as an ingredient must be labeled for its biotech content.[2] Because China is not producing biotechnology soybeans, this measure currently affects only soybeans imported from the United States and South America.

The effective date for implementation of China's biotech regulations was set for March 20, 2002. The requirement, however, was not strictly enforced until August 2003 when the government began to crack down on retailers that were violating the regulations. Since then, many retailers in the mid- to large-sized cities, such as Nanjing, Beijing, and Shanghai, have labeled products that contain biotech ingredients.

There are three different ways to satisfy the labeling requirement. According to the regulations, processed products such as soybean oil may be labeled with a statement that reads "This processed product is made from biotech soybeans." Alternatively, the statement may read "Ingredients used in the processing include biotech soybeans," or "This processed product contains biotech soybeans as an ingredient, but it no longer possesses detectable biotech content." Interestingly, both biotech and non-biotech soybean oils are available in supermarkets in Harbin—the capital city of Heilongjiang province—and lately in Beijing, but the statement for biotech soybean oil is often smaller in print size than that for non-biotech soybean oil.[3]

Detection of biotech content for labeling purposes is determined through a qualitative test measure, called the lateral flow strip test, conducted by state-owned scientific organizations, including science-and-technology universities and laboratories. This protein-based detection method takes about 10 minutes to perform and indicates the presence or absence of biotech content in food products with a "yes" or "no" response. In general, the detection sensitivity reaches 0.125% (1 kernel in 800) for most test kits under this detection method, which is lower than 0.01% (1 kernel in 10,000) inherent in a few micro-titler well test kits available in the United States.

1. *Another study using the same type of actual purchasing data is Marks, Kalaitzandonakes, and Vickner (2004).*

2. *Virtually all blended oil available in China's supermarkets contains some trace of biotech soybeans.*

3. *Labeling of non-biotech food is done on a voluntary basis. At present, it is China's policy to preserve the Heilongjiang province, along with Jilin and Liaoning, as a non-biotech soybean producing region.*

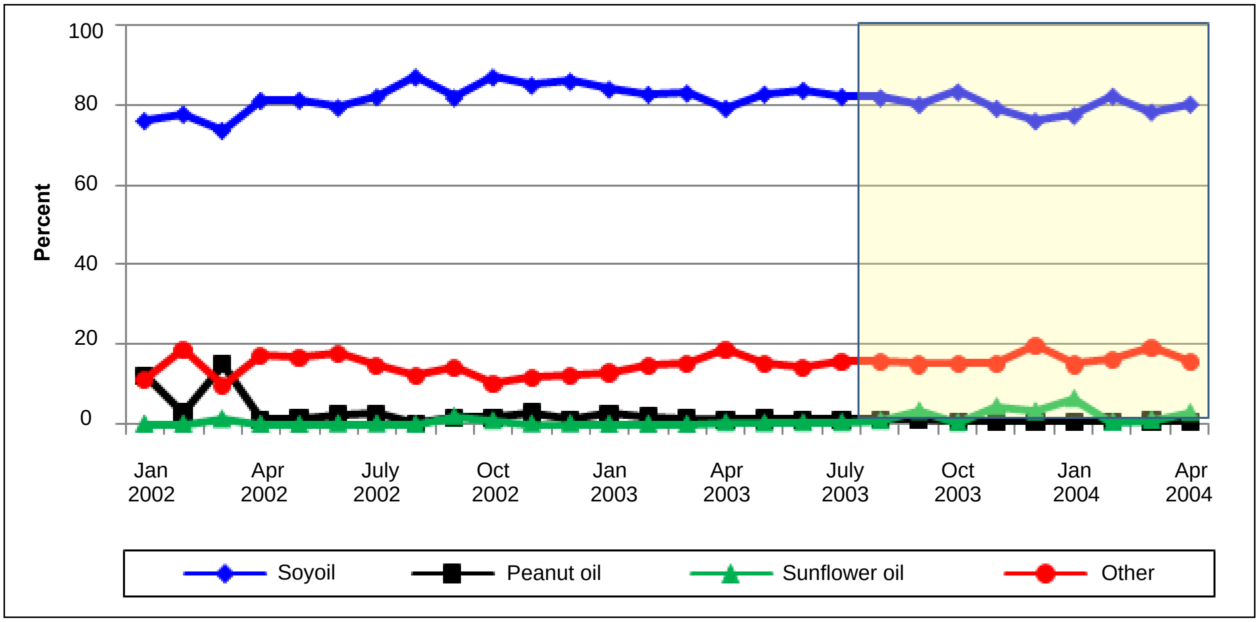

Figure 1. Expenditure shares of edible oils in Xinglong supermarket store.

It is important to also note that there are varying degrees in the accuracy of these commercially available test kits. Some governments review the test kits for accuracy and validate the kits as meeting the criteria outlined.

Supermarket Retail Scanning Data

Edible oil data in five stores were selected from more than 100 outlets of a large supermarket company in Nanjing, China. This company is a leading retail chain, operating more than 1,100 outlet stores nationwide. The Nanjing Agricultural University is responsible for maintaining and updating the retail scanning database under an agreement with this supermarket company. The five stores were randomly chosen so that they are representative of the outlet stores in Nanjing, not only in terms of socio-economic status (mainly per-household income) but also scale, radius of customer dispersion, and geographic distribution (Zhong, Chen, & Yeh, 2006). In other words, they are random, cross-section samples stratified by income, scale, and geographic considerations. These stratified random samples are highly representative of the population in Nanjing City (Zhong et al., 2006).

The retail scanning data set contains *actual* monthly aggregate sales, retail prices, and expenditures of edible oils at each of the five outlets in Nanjing during the period from January 2002 through April 2004—a total of 28 months. This sample period covers scanning data prior to August 2003—the time when mandatory labeling was strictly enforced—and thereafter fairly evenly. Hence, the cross-section (5 outlets) and time-series (28 months) data yields a total number of observations of 140. In addition to soybean oil (including blended oil that contains soybean oil as an ingredient), which averaged about 80% of all expenditures for edible oils, the data also includes peanut, sunflower, and other oils, which are regarded as non-biotech vegetable oils. Palm oil is not separated out in the scanning data because it is used mostly in food processing, although some is used as an ingredient in blended oil. Rapeseed oil, which was commonly consumed locally, is used primarily as an ingredient in blended oil and thereby is neither separated out in the database. Soybean oil (including blended oil that contain palm and rapeseed oils), peanut, and sunflower oils accounted for nearly 90% of total vegetable oil expenditures in these five outlets. While non-biotech soybean oil is currently available in Harbin and Beijing, it is currently unavailable in Nanjing's supermarkets and elsewhere.

Consumers' choice of vegetable oils for household consumption, month-by-month, reflects the effects of relative price changes among vegetable oils, household income, consumers' preferences of various vegetable oils, sales promotion, seasonable variables, and biotech labeling. During the sample period of this study, expenditure shares of soybean oil purchased by consumers from the largest sampled outlet—Xinglong supermarket store—declined slightly after August 2003, while the shares of peanut and sunflower oils had modest

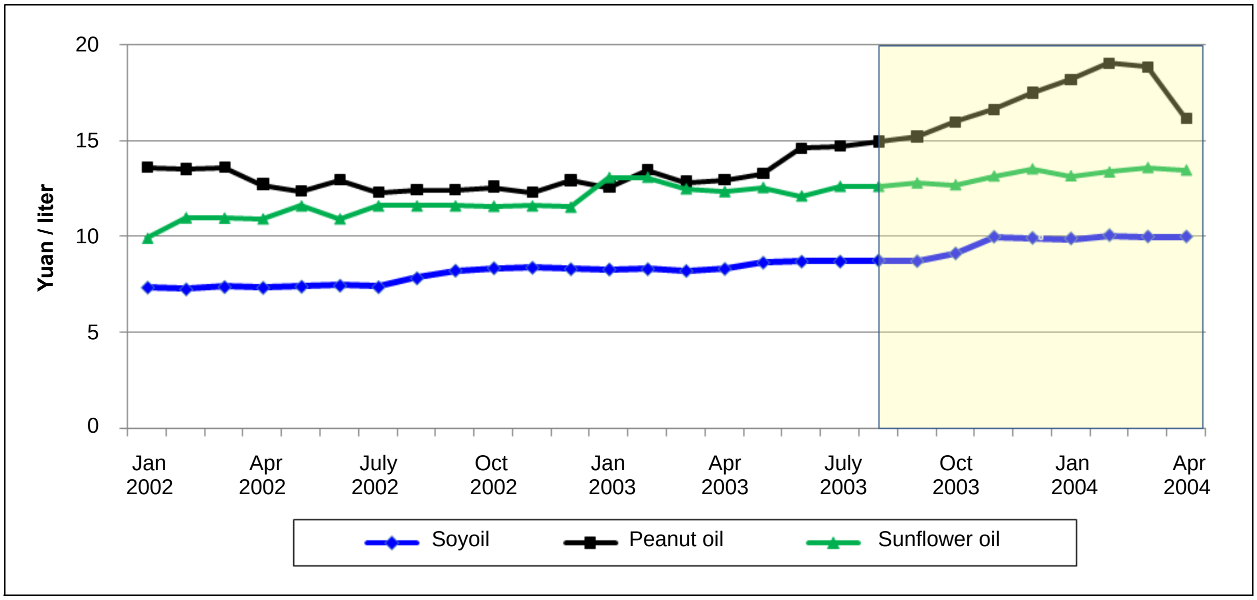

Figure 2. Retail prices of edible oils in Xinglong supermarket store.

increases (Figure 1). This pattern applies to other sampled outlet stores as well. Relative to soybean oil retail prices, sunflower oil retail prices showed a modest decline after the strict enforcement of biotech labeling (Figure 2). Soybean oil retail prices showed a faster increase after August 2003 than for sunflower oil prices. Among major vegetable oils available at supermarkets, the price of soybean oil is the lowest and the price of peanut oil the highest.

In addition to the price factor, biotech labeling and associated media coverage also appeared to have contributed to the expansion of non-biotech oil consumption. The share of non-biotech vegetable oils in terms of quantities sold expanded to 13.4% of total sales at the five sampled outlet stores by April 2004, up from 6.5% prior to the enforcement of labeling policy. In contrast, the share of biotech vegetable oils (soybean and blended oils) decreased from 93.4% to 86.6% (Figure 3). This study applies statistical tests to the above alternative causal hypotheses.

The Almost Ideal Demand System

Prior to determining the impact of biotech labeling on consumers' purchasing behavior, we developed a flexible demand system that captures the effects of all relevant variables on consumers' purchasing decisions, including own- and cross-prices of vegetable oils, household budget, consumer preferences in each of the retail outlets, seasonal variables, and sales promotion. In this context, the impact of biotech labeling is measured through a "residual" category after taking into account of the effects of all other variables.

An Almost Ideal Demand System (AIDS) for edible oils is developed, following the original work pioneered by Deaton and Muellbauer (1980) and subsequent studies (e.g., Alston & Chalfant, 1993; Eales & Unnevehr, 1994). This demand system encompasses about 20 edible oils, including soybean, peanut, sunflower, and other edible oils. Individual edible oils in this demand system are considered substitutable, but not for other foods sold by the supermarket outlets. The Appendix details the structure of this AIDS model. In addition, a list of variables and their definitions, measurement units, and expected signs are provided in Table A1.

Top-Level Demand

The AIDS demand system is conditional in the sense that the share of expenditure is contingent on category expenditure (Exp) for all edible oils, which in turn is influenced by households' budget allocation decisions among other foods and beverages, in addition to edible oils. To close the loop, it is stipulated that household operators follow a two- stage budgeting approach (Hausman & Leonard, 2005). In the first stage, the household operator decides how to allocate household budget among the various food categories. Then the operator decides how to allocate the expenditure for a given category (such as edible oils in our study) across

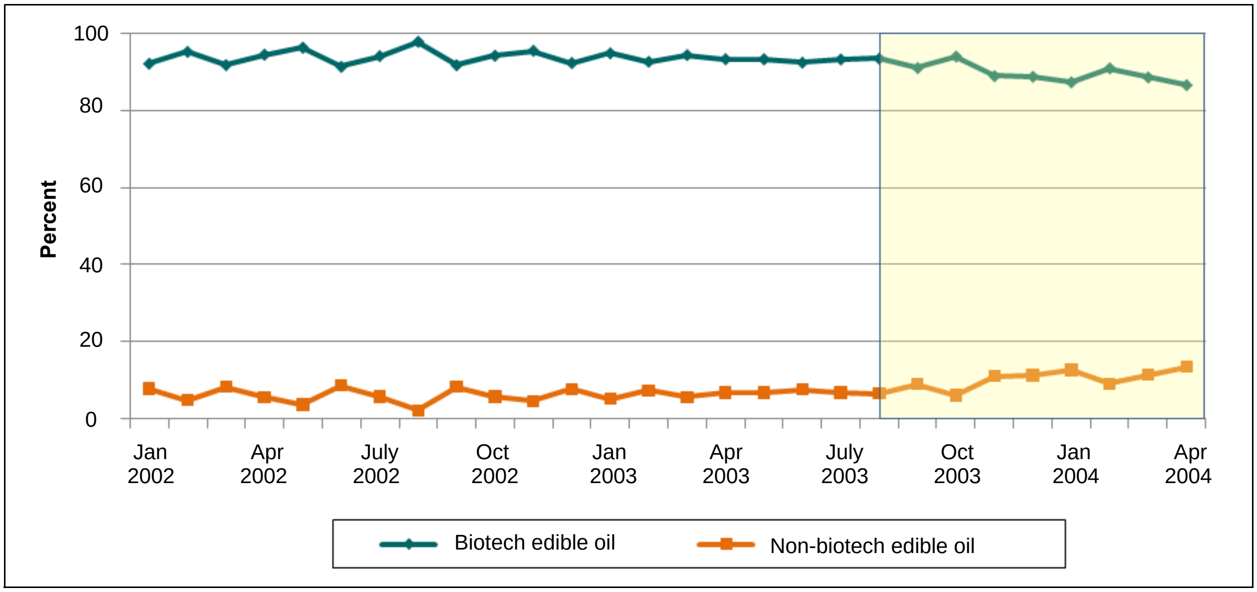

Figure 3. Market shares of edible oils in all five supermarket stores.

various edible oils. The Appendix also details the structure of the top-level demand.

Estimated Model Results

The AIDS demand system is estimated by seemingly unrelated regression (SUR) using pooled time-series (28 months) and cross-section (5 outlet stores) data. The resulting 140 observations provide sufficient degrees of freedom and the results, in general, are statistically significant.[4] Overall, the model results are robust. In comparison, the top-level demand is estimated by ordinary least squares because only a top-level demand for all vegetable oils is estimated.

AIDS Expenditure Share Equations

Empirical implementation of the AIDS expenditure share model calls for testing the hypothesis of imposing the theoretical restrictions. To the extent that the restrictions are statistically significant, such as symmetry, they are included as part of the estimation procedures.[5] This approach improves model performance and ensures that the AIDS demand system is consistent with demand theory. In this study, we found the homogeneity of degree zero restriction plays a pivotal role in yielding satisfactory results for the soybean oil share equation. In contrast, adding up constraints, by and large, did not make a noticeable difference, other than altering the intercept terms, and are not statistically significant. As a result, they are not imposed as constraints in the estimation of the parameters for the demand system.

In addition to all these theoretical constraints, we also imposed two constraints that restrict the beta coefficients of own-price variables in peanut and sunflower oil expenditure share equations at -0.4075 and -0.3163, respectively, which correspond to soybean oil's own-price expenditure elasticity of -0.124 estimated from this study (Table 1).[6] These restrictions are imposed to address multicollinearity that exists between prices of peanut and soybean oils (with a correlation coefficient of 0.81) and prices of sunflower and soybean oils (with a correlation coefficient of also 0.81).[7]

Model results suggest that edible oil prices are important factors that explain the expenditure share of vegetable oils in Nanjing, China. All own-price and cross-price variables virtually are statistically significant

4. It is desirable to expand the number of observations in future studies.

5. The theoretical constraints apply to the AIDS demand model in the context where retail scanning data are used. For an example of this kind of empirical implementation, see Hausman and Leonard (2005).

6. The assumption of applying the own-price expenditure elasticity for soybean oil to sunflower and peanut oils is plausible because (1) the greater percentage change in consumption in response to a 1% change in the price of sunflower or peanut oil, and (2) sunflower and peanut oils are priced higher than soybean oil.

Table 1. Estimated expenditure share equations for edible oils in Nanjing, China, January 2002-April 2004.

Item	OLS estimates without constraints			SUR estimates with constraints		
	Ssoy	Spea	Ssun	Ssoy	Spea	Ssun
Intercept	33.0797	-13.2077	-5.9002	78.3918	-23.5418	-16.8253
	(2.43)**	(-1.22)	(-0.80)	(15.25)***	(-2.42)**	(-3.13)**
Lnpsoy	31.0280	7.1899	8.4469	-8.0575	14.9395	8.0575
	(4.87)***	(1.37)	(2.44)**	(-3.77)***	(3.06)***	(3.77)***
Lnppea	--	1.6158	--	--	-0.4075[a]	--
		(0.66)				
Lnpsun	-6.5064	--	-4.5542	8.0575	--	-0.3163[a]
	(-1.06)		(-1.36)	(3.77)***		
Lndfexp	0.6156	-0.2679	0.0124	0.4940	-0.3279	0.3259
	(0.49)	(-0.40)	(0.02)	(0.40)	(-0.50)	(0.46)
Trend	--	-0.2027	--	--	-0.2375	--
		(-2.87)***			(-3.50)***	
Dspf	-0.9911	0.6803	0.5196	-0.1793	0.6521	0.4753
	(-1.13)	(1.46)	(1.08)	(-0.21)	(1.43)	(1.00)
Dmida	--	--	1.3496	--	--	1.1182
			(1.86)*			(1.84)*
Dhpea	-17.0189	27.5821	--	-18.4390	27.8259	--
	(-4.59)***	(14.11)***		(-5.91)***	(14.30)***	
Dhsun	-19.7275	--	26.6302	-17.4808	--	26.2359
	(-7.37)***		(18.42)***	(-6.84)***		(18.29)***
Dlabel	-7.2999	-0.1650	2.7829	**-1.7533**	-0.6527	**2.3409**
	(-6.56)***	(-0.24)	(4.60)***	**(-2.59)****	(-1.11)	**(4.34)*****
D1	- 2.0575	0.7381	-0.5734	-1.2553	0.8300	-0.6097
	(-2.09)**	(1.35)	(-1.06)	(-1.29)	(1.63)	(-1.14)
D2	-7.7378	2.5632	2.8511	-7.7241	2.6845	2.7437
	(-8.08)***	(4.97)***	(5.44)***	(-8.11)***	(5.39)***	(5.29)***
D3	-1.9987	0.0331	-0.6649	-1.6297	0.1367	-0.8066
	(-1.79)*	(0.05)	(-1.06)	(-1.47)	(0.24)	(-1.31)

[a] No t-ratio is shown due to a restriction of this beta coefficient at -0.4000, which implies that the own-price demand elasticity for soybean oil is also applicable to peanut oil.
, **, and * denote statistically significant at 10%, 5%, and 1%, respectively.*

at the 1% level and their beta coefficients have expected signs (Table 1).[8] Soybean oil is the most important substitute for peanut and sunflower oils, reflecting the statistical significance of the beta coefficients of the soybean oil price variable. Not surprisingly, deflated category expenditure for all edible oils does not have significant impact on edible oils' expenditure share because edible oils account for a small proportion of household budget for food consumption.

It is interesting to note that biotech labeling is found to reduce the expenditure share of soybean and blended oils by nearly 2 percentage points, lower than the 4 per-

7. The peanut oil price variable is excluded due to its high correlation with other vegetable oil prices, which yield a beta coefficient that is statistically insignificant if included in the soybean oil expenditure share equation. Including this variable does not appreciatively alter the beta coefficient of the labeling dummy. Since soybean oil (including blended oil) accounts for nearly 90% of all edible oil market shares, and rapeseed and palm oils are mostly blended with soybean oil, prices of edible oils other than soybean, rapeseed, palm, peanut and sunflower exert little effect on the choice of edible oils by consumers in Nanjing city.

8. Most of the price variables are not statistically significant without theoretical constraints being imposed.

centage points reported previously by Zhong et al. (2006), which regresses the consumption share of vegetable oils against own- and cross-prices, and other pertinent variables without imposing theoretical constraints, and 7 percentage points estimated by ordinary least squares (OLS) without imposing the theoretical constrains in this study (Table 1). Meanwhile, the expenditures share for sunflower oil increases by 2.3 percentage points, but that for peanut oil is not impacted by biotech labeling. This finding suggests that sunflower oil is more a direct substitute for soybean oil than peanut oil for consumers at the selected five outlets in Nanjing city. Effects of the prices of rapeseed and palm oils on the choice of edible oils are less discernable because the former is primarily used an ingredient in blended oil which is combined with soybean oil and the latter, if not used in food processing, is also used an ingredient in blended oil. All blended oils virtually contain traces of soybean oil and thereby require biotech labeling.

In short, this study concludes that biotech labeling does not appreciably discourage urban consumers in China from purchasing soybean oil made from biotech soybeans, which at this point are imported from the United States and South America. This finding is consistent with a favorable consumer acceptance of biotech soybean oil by urban consumers in China (Lin et al., 2006a); 77.4% of the respondents in a consumer survey were supportive of biotech foods—that is, they found biotech foods to be acceptable or neutral. Only 12.6% of them were opposed to biotech foods, and the remaining 10.1% were undetermined. It is conceivable that urban consumers who were opposed to biotech foods are more prone to paying attention to biotech labeling on foods they purchased. However, these consumers account for only a modest percentage of urban population. As a result, while some of these consumers might switch from biotech to non-biotech vegetable oils stemming from labeling, the extent of the switch is likely to be small.

This finding also suggests that the current market for US soybean exports to China is unlikely to be affected by enforcement of biotech labeling regulations in that country. Widespread acceptance of biotech foods by urban consumers in China has important implications for the decision by Chinese food manufacturers and retailers to use and label biotech foods. In this study, the small percentage of urban consumers we found who are likely to switch from biotech to non-biotech vegetable oils suggests that many food manufacturers and retailers in China would use less costly biotech ingredients and label products accordingly. This decision to label biotech products would, by and large, facilitate the export of China-approved biotech products (such as herbicide-tolerant soybeans) from the United States without incurring additional expenses in segregating biotech from non-biotech products.

Table 2. Estimated top-level demand for edible oils in Nanjing, China.

Item	Log Q_j (consumption of edible oils)		
	$\delta_j = -0.05$	$\delta_j = -0.10$	$\delta_j = -0.20$
Intercept	21.373	21.473	21.672
	(5.91)***	(5.93)***	(5.99)***
Log P_j	-0.050[a]	-0.100[a]	-0.200[a]
Log EXP	-1.770	-1.769	-1.767
	(-3.21)***	(-3.21)***	(-3.20)***
Trend	0.014	0.014	0.015
	(1.83)*	(1.90)*	(2.03)*

** and *** denote statistically significant at 10% and 1%, respectively.*

[a] The beta coefficient is restricted to a value that is lower than the demand price elasticity for soybean oil—the predominant edible oil.

Top-Level Demand Equation

The top-level demand is estimated by ordinary least squares using a typical log-log specification. The dependent variable is overall quantity of supermarket vegetable oils consumed in Nanjing in a specific month and the price variable is the weighted price of vegetable oils. Since total household expenditures are often not available by city, per capita disposable income in Nanjing is used as a proxy. Both price and income variables are deflated by the CPI for Nanjing.[9]

Multicollinearity between the price and trend variables (with a correlation coefficient of 0.75) necessitates the imposition of a constraint on the beta coefficient of the price variable. It is hypothesized that the aggregate demand price elasticity for vegetable oils would be smaller than that for an individual vegetable oil. Using soybean oil as the reference case, soybean oil's own-price elasticity would be -0.377 (see later discussion) if the aggregate demand price elasticity is -0.10—our base case (Table 2). Halving or doubling this aggregate demand elasticity assumption does not materially alter the regression results for the top-level demand equation. Deflated per capita disposable income is a statistically significant factor that affects the aggregate demand for

9. *Both per-capita disposable income and CPI data were obtained from the provincial government of Jiangsu.*

supermarket vegetable oils. As per capita income increases 1%, aggregate demand for vegetable oils decreases by nearly 1.8%. The negative income elasticity is not unexpected because consumers are more prone to eat foods away from home as their incomes increase, thereby reducing purchases of vegetable oils for family cooking.[10] However, the magnitude of income elasticity is expected to become smaller once consumption of vegetable oils is extended to include those used in food processing and foods consumed away from homes. Model results further suggest that consumption of vegetable oils among urban consumers in Nanjing city is increasing.

Demand Price Elasticities

Own- and cross-price demand elasticities can be estimated from AIDS expenditure shares and top-level demand equations. With the AIDS demand model and the linear approximation of the non-linear function of the log price variable via the Stone price index, own- and cross-price elasticities are (Hausman & Leonard, 2005):

Own-Price:

$$e_{ii} = 1/S_i\,[\gamma_{ii} - \beta_i S_i] - 1 + [1 + \beta_i/S_i](1+\delta)\,S_i \text{ for } i = j \quad (1)$$

Cross-Price:

$$e_{ij} = 1/S_i\,[\gamma_{ij} - \beta_i S_j] + [1 + \beta_i/S_i](1+\delta)\,S_j \text{ for } i \neq j \quad (2)$$

All demand price elasticities are well-behaved, robust, and have expected signs (Table 3). The own-price demand elasticity for soybean oil is estimated at -0.377, which is plausible given that edible oil is a necessity and soybean oil plays a dominant role. As expected, own-price elasticities for peanut and sunflower oils are greater than that for soybean oil. Demand for peanut or sunflower oil is particularly responsive to soybean oil price changes due to small base.

These own- and cross-price demand elasticities, in general, are comparable with those reported by Fang and Beghin (2002, p.746). The own-price elasticity of -0.377 for soybean oil estimated here is not much different from the -0.604 in their study. Also, the 0.123 cross-price elasticity of soybean oil consumption with respect to the price of sunflower is similar to the 0.168 in their study, where rapeseed oil is considered as a substitute for soybean oil.

Table 3. Estimated own- and cross-price demand elasticities for vegetable oils in Nanjing, China.[a]

Consumption	With respect to the price of:		
	Soybean oil	Sunflower oil	Peanut oil
Soybean oil	-0.377	0.123	--
Sunflower oil	3.874	-0.849	--
Peanut oil	5.356	--	-1.098

[a] These elasticities are estimated by restricting the aggregate demand price elasticity for all edible oil at -0.100. Varying this parameter value up and down does not appreciatively alter estimated demand elasticities.

Conclusions

In this study, biotech labeling is found to have only a modest impact in lowering the consumption of soybean oil in Nanjing, China. The relatively small cross-price elasticity for the demand for soybean oil with respect to the change in price for its main substitute—sunflower oil—suggests that the two vegetable oils are not close substitutes in the eyes of urban consumers in Nanjing. This modest cross-price demand elasticity supports a small impact on consumers' purchasing behavior in the case of vegetable oils in this city.

Perhaps the clearest evidence that there is no significant impact of biotech labeling on consumers' purchasing behavior is that soybean imports into China roughly doubled in the years after the labeling regulations were imposed. Soybean oil prices have not fallen relative to rapeseed oil prices, so demand has apparently kept up with the growth in supply. Therefore, there is apparently no aversion to consumption of vegetable oils with biotech content.

The case study results indicate that the impact of biotech labeling might be even smaller for consumers in smaller-sized cities and rural areas. In previous studies, consumers in smaller-sized cities were found to be more willing to accept biotech foods than those residing in larger cities, and those in rural areas probably are even more price-sensitive (Lin et al., 2006a). Including those consumers in this analysis, therefore, would have indicated an even smaller impact of biotech labeling on consumer purchasing in China.

Results from the AIDS demand model suggest that vegetable oil prices are important factors affecting consumers' purchasing decisions for vegetable oils. However, demand for soybean oil is inelastic. Other than rapeseed oil, which is mixed in the blended oil and thus

10. The magnitude of income elasticity appears to be greater than other studies based on cross-section data.

is undifferentiated from soybean oil in the scanning data, the main substitute for oils containing biotech soybeans is sunflower oil. Also, household budget constraints exert little effect on their purchasing behavior because vegetable oils account for a small fraction of total household budget.

The rapid changes in the structure of supermarkets in China suggest a need to update this kind of analysis. Supermarkets in mid- to large-sized cities have expanded their sizes, and are offering more diverse food products and more ready-to-eat processed products for the convenience of consumers. This suggests a need in future studies for continuing to update the labeling impact by including observations in more recent months after the strict enforcement of the biotech labeling requirement in August 2003. Similarly, differences in the structure of supermarkets across locations suggest extending this kind of analysis to other cities in China, such as Beijing and Shanghai.

References

Alston, J.M., & Chalfant, J.A. (1993). The silence of the lambdas: A test of the almost ideal and Rotterdam models. *American Journal of Agricultural Economics*, *75*, 304-313.

Asian Food Information Center. (2004, January 12). *Attitude to food biotechnology: The Philippines, China and India*. ISIS Research.

Bai, J. (2003). Consumers' acceptance of and willingness to buy genetically modified foods in urban China. Master's thesis, Center for Chinese Agricultural Policy, Chinese Academy of Sciences, Beijing, China.

Chern, W.S., Rickertsen, K., Tsuboi, N., & Fu, T. (2003). Consumer acceptance and willingness to pay for genetically modified vegetable oil and salmon: A multiple-country assessment. *AgBioForum*, *5*(3), 105-112. Available on the World Wide Web: http://www.agbioforum.org.

Deaton, A., & Muellbauer, J. (1980). An almost ideal demand system. *American Economic Review*, *70*, 312-326.

Ding, Y. (2004). *A Nanjing case study of Chinese consumers' attitudes toward GM foods*. Master thesis, Nanjing Agricultural University, Nanjing, China.

Eales, J.S., & Unnevehr, L.J. (1994). The inverse almost ideal demand system. *European Economic Review*, *38*, 101-115.

Fang, C., & Beghin, J.C. (2002). Urban demand for edible oils and fats in China: Evidence from household survey data. *Journal of Comparative Economics*, *30*, 732-753.

Golan, E., Kuchler, F., & Mitchell, L. (2000, December). *Economics of foods labeling* (Agricultural Economics Rep. No. 793). Washington, DC: USDA ERS.

Greene, W. (1990). *Econometric analysis*. New York: Macmillan Publishing Company.

Hausman, J.A., & Leonard, G.K. (2005). Competitive analysis using a flexible demand specification. *Journal of Competition Law and Economics*, *1*(2), 279-301.

International Food Information Council (IFIC). (2004, March 8). *IFIC survey: Support for food biotechnology stable despite news on unrelated food safety issues*. IFIC Background.

Li, Q., Curtis, K.R., McCluskey, J.J. & Wahl, T.I. (2003). Consumer attitudes toward genetically modified foods in Beijing, China. *AgBioForum*, *5*(4), 145-152. Available on the World Wide Web: http://www.agbioforum.org.

Lin, W., Somwaru, A., Tuan, F., Huang, J., & Bai, J. (2006a). Consumer attitudes toward biotech foods in China. *Journal of International Food and Agribusiness Marketing*, *18*(1&2).

Lin, W., Somwaru, A., Tuan, F., Huang, J., & Bai, J. (2006b). Consumers' willingness to pay for biotech foods in China: A contingent valuation approach. *AgBioForum*, *9*(3), 166-179.

Lusk, J.L. (2003). Effects of cheap talk on consumer willingness-to-pay for golden rice. *American Journal of Agricultural Economics*, *85*(4), 840-856.

Maddala, G.S. (1977). *Econometrics*. New York: McGraw-Hill.

Marchant, M.A., Fang, C. & Song, B. (2003). Issues on adoption, import regulations, and policies for biotech commodities in China with a focus on soybeans. *AgBioForum*, *5*(4), 167-174. Available on the World Wide Web: http://www.agbioforum.org.

Marks, L.A., Kalaitzandonakes, N., & Vickner, S. (2004). Consumer purchasing behavior toward GM foods in Europe. In R. Evenson & V. Santaniello (Eds.), *Consumer acceptance of biotech foods*. Wallingford, UK: CABI Publishers, pp. 23-39.

Shoemaker, R., Johnson, D.D., & Golan, E. (2003). Consumers and the future of biotech foods in the United States. *Amber Waves*, *1*(5), 30-36.

Zhong, F., Chen, X., & Yeh, X. (2006). *Biotech food labeling and consumers' purchasing behavior: A case study of supermarket vegetable oil actual sales data in Nanjing, China* (working paper). Nanjing Agricultural University, Nanjing, China.

Zhong, F., Marchant, M., Ding, Y. & Lu, K. (2002). GM foods: A Nanjing case study of Chinese consumers' awareness and potential attitudes. *AgBioForum*, *5*(4), 136-144. Available on the World Wide Web: http://www.agbioforum.org.

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Appendix: The Almost Ideal Demand System

An Almost Ideal Demand System (AIDS) for edible oils is developed, following the original work pioneered by Deaton and Muellbauer (1980) and subsequent studies (e.g., Alston & Chalfant, 1993; Eales & Unnevehr, 1994). This demand system encompasses about 20 edible oils, including soybean, peanut, sunflower, and other edible oils. Individual edible oils in this demand system are considered substitutable, but not for other foods sold by the supermarket outlets. Under the AIDS, expenditure share (S_i) of the ith edible oil is specified as:

$$S_i = \alpha_i + \beta_i \log(\mathrm{Exp/Price}) + \sum_{j=1}^{N} \gamma_{ij} \log P_j + \sum_{k=1}^{K} \varphi_{ik} Z_k + \rho_i D_{label} + \varepsilon_i \quad (3)$$

where S_i = share of edible oil *i*'s expenditure relative to total expenditure for all edible oils; Exp = total expenditure for all edible oils; Price = composite average price of all edible oils weighted by mean expenditure shares of individual oils; dfexp = deflated total expenditure for all edible oils; P_j = retail prices of the jth edible oil; Z_k = a vector of time trend (January 2002=1, …April 2004 = 28), seasonal variables—such as Chinese spring festival (January or February = 1, else = 0) and mid-autumn festival (September = 1, else = 0), months of an extraordinary high expenditure share for specific edible oils that was attributed to sales promotion , and outlet-specific fixed effects; and D_{label} = biotech labeling dummy (August 2003 and thereafter = 1, else = 0).

A list of variables as shown in Table 1 and their definitions are given in Table A1. Also, measurement units and expected signs in the expenditure share equations are indicated.

Under AIDS, the log price variable has the following non-linear form:

$$\log P = \alpha_0 + \sum_{i=1}^{N} \alpha_i \log P_i + \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_{ij} \log P_i \cdot \log P_j \quad (4)$$

However, as it is usually done, a linear approximation to this non-linear function via the "Stone price index" is adopted in this study, which is a weighted average of the individual vegetable oil prices, using the vegetable oils' expenditure shares as weights (Deaton & Muellbauer, 1980):[11]

$$\log P = \sum_{i=1}^{N} S_i \log P_i \quad (5)$$

This demand system is then estimated by SUR, which explicitly recognizes that residual terms across various edible oils' share equations are interrelated (Greene, 1990; Maddala, 1977). Theoretical constraints can be imposed and tested on the relationships of specific parameters, which are incorporated into the estimation procedures, including:

Symmetry: $\gamma_{ij} = \gamma_{ji}$ for all i's and j's

Homogeneity of degree zero: $\sum_{j=1}^{N} \gamma_{ij} = 0$ for i = 1, 2,...N

Adding up: $\sum_{i=1}^{N} \alpha_i = 1$, $\sum_{i=1}^{N} \beta_i = 0$, and $\sum_{i=1}^{N} \gamma_{ij} = 0$

Slutsky symmetry requires that the compensated cross-price derivative of vegetable oil A with respect to vegetable oil B equals the compensated cross-price derivative of vegetable oil B with respect to vegetable oil A (Hausman & Leonard, 2005). The constraint of homogeneity of degree zero indicates that the expenditure share for each of the edible oils will not change if total expenditure for all vegetable oils (Exp), and all prices are changed by the same percentage. Intuitively, this constraint means that in the absence of changes in relative prices of vegetable oils and "real" expenditure for all vegetable oils, the expenditure shares are constant (Deaton & Muellbauer, 1980). Adding up implies that the expenditure shares must sum to one across individual edible oils.

AIDS at an aggregate level involves summing over consumers. Parameters estimated for AIDS demand system are weighted averages of individual consumers (Deaton & Muellbauer, 1980; Hausman & Leonard, 2005). As a result, AIDS estimated on aggregate-level data can be treated as the demand system for a representative consumer. In fact, AIDS demand system would be preferred to other alternatives, such as the logit model, Rotterdam model, and translog model, if aggregate-level data—such as retail scanning data—are used (Hausman & Leonard, 2005).

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11. The weights are equal to the average of the expenditure shares over the entire sample period in this study. This fixed-weight scheme avoids inducing endogeneity in the log price variable.

Table A1. Definitions of the variables in the AIDS model.

Variable	Definition	Unit	Expected sign
Ssoy	Share of soyoil relative to total expenditure for all edible oils	Fraction	
Spea	Share of peanut oil relative to total expenditure for all edible oils	Fraction	
Ssun	Share of sunflower oil relative to total expenditure for all edible oils	Fraction	
psoy	Retail prices of soyoil	Yuan, RMB Per liter	Own-price – Cross-price +
ppea	Retail prices of peanut oil	"	"
psun	Retail prices of sunflower oil	"	"
dfexp	Total expenditure for all edible oils deflated by composite average price of all edible oils	Liter	+
Trend	Time trend (January 2002=1,…, April 2004=28)		+ or –
Dspf	Dummy variable for Chinese spring festival (January or February=1, else=0)	1 or 0	+
Dmida	Dummy variable for mid-autumn festival (September=1, else=0)	1 or 0	+
Dhpea	Dummy variable for months of an extraordinary high expenditure share for peanut oil due to sales promotion	1 or 0	Own + Cross –
Dhsun	Dummy variable for months of an extraordinary high expenditure share for sunflower oil due to sales promotion	1 or 0	Own + Cross –
Dlabel	Biotech labeling dummy (August 2003 and thereafter=1, else=0)	1 or 0	Soybean oil eq. – Peanut oil eq. + Sunflower oil eq. +
D1	Outlet-specific fixed effect (Weigang store=1, else=0)	1 or 0	+ or –
D2	Outlet-specific fixed effect (Quichi store=1, else=0)	1 or 0	+ or –
D3	Outlet-specific fixed effect (Xinglong store=1, else=0)	1 or 0	+ or –

Top-Level Demand

The AIDS demand system is conditional in the sense that the share of expenditure is contingent on category expenditure (Exp) for all edible oils, which in turn is influenced by households' budget allocation decisions among other foods and beverages, in addition to edible oils. To close the loop, it is stipulated that household operators follow a two-stage budgeting approach (Hausman & Leonard, 2005). In the first stage, the household operator decides how to allocate household budget among the various food categories. Then the operator decides how to allocate the expenditure for a given category (such as edible oils in our study) across various edible oils. This top-level demand for the j^{th} category aggregate demand (including one for all edible oils) is typically specified as:

$$\log Q_j = \delta_0 + \delta_j \log P_j + \lambda \log EXP + \sum_{k=1}^{K} \varphi_K Z_k + \eta_j \qquad (6)$$

where Q_j is overall quantity for the j^{th} category product, P_j is the composite average price of all products in the j^{th} category using the vegetable oils' consumption quantities as weights, EXP is total expenditure for all products (equivalent to household income being allocated for consumption of all consumer products), Z_k is the vector of time trend (Trend) and seasonal variables, and η_j is an error term. These variables that appear in Table 2 are defined as above. All income and price variables are deflated by consumer price index (CPI).