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Foodborne Disease Outbreaks and Consumer Purchases

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Using a large product-level scanner data set from a national grocery chain, we examine how consumers in California reacted to three consecutive egg recalls during the 2010 Salmonella outbreak. We find a 9% significant reduction in egg sales. Given an overall price elasticity for eggs in U.S. households of around -0.1, this sales reduction is comparable to an almost 100% increase in price.

Also in this issue

When making purchasing decisions about products, consumers traditionally include factors such as price, quality, and availability of substitutes. It is less clear what happens when a very similar product is removed from the market for safety reasons. On the one hand, if a product with safety concerns is removed from the market and the remaining products experience additional safety checks, consumers may perceive the market as being at least as safe as before. On the other hand, if the removal of the unsafe product provides negative information about closely related products or the industry as a whole, consumers may respond by decreasing demand, even in the absence of safety concerns about the remaining products.

The empirical question is whether a recall of an unsafe product can have a direct impact on consumer purchases and preferences, even if the remaining products are safe. From a safety perspective, the question is relevant if firm incentives to invest in risk reduction and regulatory compliance in existing regulation depend, to some degree, on consumer responses to recalls.

The Egg Recalls

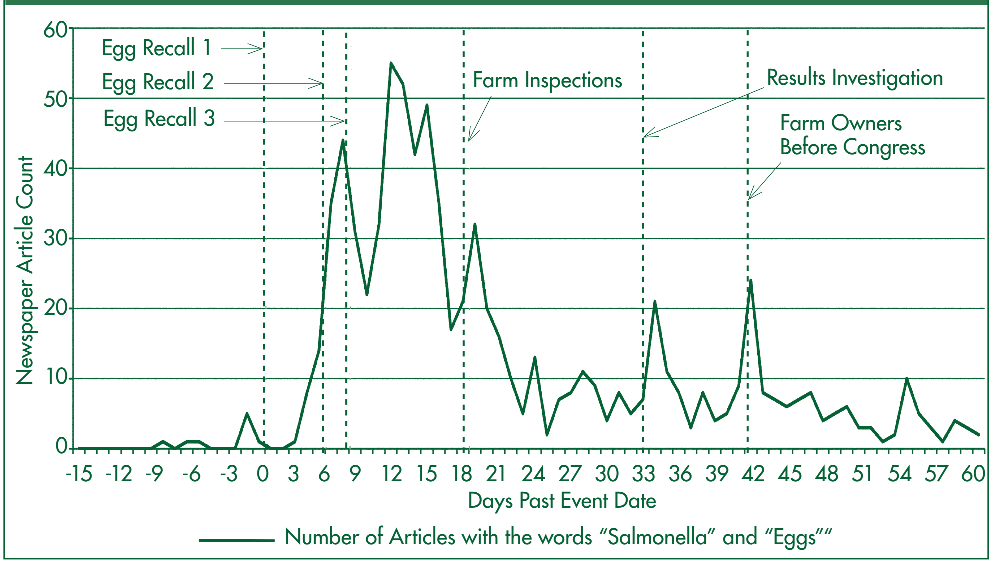
In early July 2010, the Center for Disease Control and Prevention (CDC) identified a nationwide, four-fold abnormal increase in the number of reported Salmonella infections. A month later, on August 13, 2010, a first egg farm, located in Iowa, conducted a nationwide voluntary recall of around 228 million eggs. By August 18, 2010, the same farm expanded its recall to around 152 million additional eggs. Within 48 hours, on August 20, 2010, a second egg farm, also located in Iowa, conducted another nationwide voluntary recall of around 170 million eggs.

In total, from August 13 to August 20, 2010, more than 500 million eggs were recalled, in what would be the largest egg recall in U.S. history (around 0.7% of production). Infected eggs from these two major egg producers were distributed in fourteen U.S. states, including California. Eggs were recalled using specific plant numbers and codes that allowed tracing back to the box level, leaving no infected eggs in stores. Consumers and stores could return infected eggs for a full refund.

The three egg recalls received extensive national and local media coverage on the television, radio, newspapers, and the Internet. To measure media coverage of the event, we conducted a Lexis-Nexis search, which gave us the daily count of newspaper articles that appeared on the 2010 Salmonella egg outbreak, starting 15 days before the event up to 60 days after the event.

Figure 1 shows the number of articles in major newspapers that include the words “Salmonella” and “Eggs” on a given day. Media interest persisted over a six-week period following the event,

Figure 1. Newspaper Coverage of the 2010 Salmonella Egg Outbreak



in particular covering farm inspections that found numerous violations and showed that the egg farms were infested with flies, maggots, rodents and overflowing manure pits, as well as both farm owners testifying before Congress.

The fact that there were three consecutive egg recalls within one week could have led consumers to think that this was a major outbreak, and not a regular food recall. Furthermore, given the information provided by the media coverage, some consumers may have obtained information or updated their beliefs on the egg industry as a whole.

If consumers were perfectly informed, did not update their beliefs, and expected no further recalls, we could anticipate no effect of the event on consumer purchases. However, if consumers did not have perfect information on the outbreak or the recall codes, updated their beliefs about the egg industry, or "overreacted" to the recalls, we could expect a drop in egg purchases following the event, at least temporarily. We find that the latter was true.

Empirical Strategy

Using a unique product-level scanner data set of a national grocery chain that has stores in both high and low income zip codes, we examine how consumers reacted to the three consecutive egg recalls. First, we test whether consumers changed their egg purchases in California following the recalls. We examine media coverage on the highly publicized outbreak and hypothesize that media coverage is the channel through which consumers became informed about the event.

Second, we study whether consumers substitute away from conventional eggs towards other types of specialty "greener" eggs that may be perceived as having a lower probability of Salmonella, such as organic or cage-free eggs. Eggs are currently produced under a variety of methods, but 95% of the national egg production in 2010 came from conventional battery cages. In our California and Washington sample, around 90% of eggs sold came from battery cages.

Table 1 summarizes some of the differences between conventional eggs and non-conventional eggs. It is unclear if consumers were aware of the debate in the United States about the link between the type of egg (e.g., from a battery cage, cage-free, organic) and the probabilities of Salmonella infection.

We hypothesize two possible results for purchases of unaffected eggs. On one hand, consumers might substitute away from conventional types of eggs to non-conventional specialty eggs (a substitution effect across egg classes). On the other hand, some consumers might choose to reduce all egg purchases, leading to a decline in purchases of all types of eggs.

Third, we investigate whether different socio-economic groups reacted differently to the egg recalls. In particular, we look at whether income and household size affect the response to the recalls. To do this, we use demographic data for the zip code where the store is located. Income may affect the response if wealthier consumers are able to substitute to greener alternatives, which can cost up to twice as much as traditional shell eggs.

Finally, we examine whether separate areas within California reacted differently to the egg recalls. Due to its distribution system, our national grocery chain had infected eggs only in Northern California. We use variation within California to test whether consumers in Southern California reduced egg purchases as well.

We use a technique known as differences-in-differences to estimate the effect of the three recalls on egg sales and use a control state that did not receive infected eggs, Washington. We are also able to control for seasonality (i.e., seasonal changes that could be occurring at the time of the event in California) by using data from previous years around the event date. The differences-in-differences approach consists in comparing changes in egg purchases in affected areas in California to changes of egg purchases in comparable but recall-unaffected areas in Washington.

If we were to focus only on the changes in California, we could not conclude that those changes were caused by the recalls. We could only show that they are correlated with the recalls. Indeed, other confounding factors, such as macroeconomic conditions, could be responsible for changes in California egg purchases. We net out such factors by using changes for comparable stores in Washington as counterfactuals.

We use the fact that infected eggs could be traced to the box level to establish a clear definition of the treatment and follow a panel of over 600 stores during a four-year period. Further, given the geographical distribution of infected eggs, we are able to measure potential spillovers to unaffected areas of California.

Findings

We begin by plotting the evolution of daily sales around the "event week" (August 13–August 20, 2010) in California. Figure 2 plots changes in egg purchases (in quantities of egg boxes sold) for all shell eggs for stores in California only. The category all shell eggs includes 2 classes (all traditional or value-added specialty eggs) and 7 subclasses (traditional large, traditional extra-large, traditional jumbo, specialty brown, specialty organic, specialty cage-free and specialty nutrient-enhanced). The figure plots data starting 30 days before the "event day" (here defined as August 13, 2010, the day of the first egg recall) up to 35 days after the event day.

Changes in egg purchases take into account price, as well as factors that are constant across stores, aggregation levels and day of the week (e.g., sales are always higher on weekends). Egg sales show a large drop a few days after the first recall and a small increase between the second egg recall and the third recall. Sales reach their lowest level in the time period around 11 days after the first egg recall. This suggests that, if egg purchases decreased due to the egg recalls, there was a small (days) time-lag between the time the recalls were made and the time that the effect was reflected in lower purchases in stores.

Using our econometric model, we proceed to formally test the effect of the three egg recalls and find a 9% significant reduction in egg sales in California. Given an overall price elasticity for eggs in U.S. households of around -0.1, this sales reduction is comparable to an almost 100% increase in price. Consistent with a rather inelastic demand, the effect is very similar with and without prices.

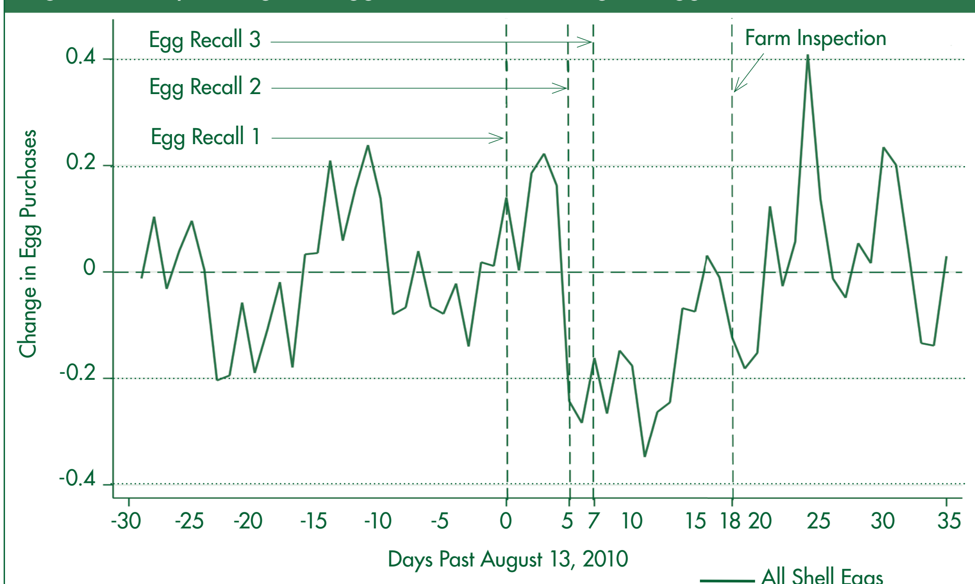
We find that the decrease in sales was driven by a drop in purchases of traditional large shell eggs and find no evidence of substitution toward other greener type of eggs, such as organic or cage-free eggs. More specifically, we find that purchases of large traditional shell eggs significantly decreased by 10% in California in the month following the event. Large traditional eggs had the largest market share of sales in our sample in 2009 (around 70%). Sales of the other types of eggs do not change significantly due to the recalls. For jumbo, brown, cage-free and nutrient-enhanced eggs (with very small 2009 baseline sales), we find no significant effects of the recalls. Sales for extra-large traditional shell eggs and for organic eggs seem higher but the recalls still have no significant effect.

Table Conventional and Non-Conventional Eggs

Conventional Eggs	Non-Conventional Eggs
• 95% of the egg production in 2010 came from conventional battery cages. • Conventional battery cages are stacks of cages that can be up to two stories high and keep about six hens to a cage. • Each hen gets on average 67 square inches of floor space (about ¾ of a sheet of a notebook paper). • Hens are unable to fully stretch their wings and have no access to natural light. • As many as 100,000 birds may be grouped together under a single roof (USDA).	• 5% of egg production comes from non-conventional production methods. • Methods are classified by: o how eggs are raised (e.g., cage-free, free-range, pasture-raised), and/or o by what birds are fed (e.g., organic, vegetarian-fed, no hormones, no antibiotics) • A single egg box usually contains more than one label (e.g., "Cage-Free, Kosher and Vegetarian-fed hens").

Sources: United Egg Producers (UEP) and USDA, ERS

Figure 2. Daily Changes in Egg Purchases Following the Egg Recalls



When matching each grocery store with the socio-economic characteristics of the zip code in which it is located, we are able to investigate heterogeneous effects of the recall. We study whether income and household size affect the response to the recalls, where income is the demeaned average income in the zip code in which the store is located (in 10,000 USD) and household size is the demeaned average household size in the zip code in which the store is located. Socio-economic data come from the 2000 U.S. Census. While we find no correlation with income, we do find that areas that had a larger than average household size decreased egg purchases significantly more.

A caveat to the results is that it is possible that more affluent customers diverted egg purchases to farmers' markets or high-end grocery stores after the egg recalls and thus the estimates would suffer from selection bias. The data allow only for the identification of effects with purchases undertaken at the national grocery chain.

We also find differentiated effects among Northern and Southern Californian stores. Although the national grocery chain had infected eggs only in Northern California, we find that Southern Californian stores had lower egg sales as well. The overall sales reduction in Southern California was half as large as the reduction in Northern California, and is consistent with media and reputation effects being significant determinants of demand, even in the absence of an actual food recall.

Studies on the effects of safety warnings on spinach (Arnade et al. 2009), beef (Schlenker and Villas-Boas 2009) or fish (Shimshack et al. 2007) have also found significant consumer responses. However, the persistence of the effect may vary depending on the type of good and availability of substitutes. For example, while the effect of a safety warning on spinach had a long-term effect, our results for eggs suggest that the effect was temporary.

To test the robustness of our findings, we perform several checks. First, we test the sensitivity of the baseline results to various assumptions about the seasonality parameters. We use only data for one year before the recall (2009) instead of using, as above, all previous years (2007, 2008, and 2009). This yields very similar drops in purchases as when we include all previous years.

Second, we test the sensitivity of the baseline results to using Washington as a control state by excluding data from Washington and using stores in Southern California as controls. The rationale is that we may assume that stores in Southern California have similar trends to stores in Northern California. Once again, using Southern California stores as counterfactuals for Northern California store patterns yields very similar estimates of the egg recalls.

Third, we test the sensitivity of the baseline results to using only one month after the event week. We obtain data on a second post-event month and include a total of eight weeks after the event week for all years. While this additional robustness check gives us similar results to the ones from the main specification, we find that the effect lasted more than one month.

Conclusion

Consistent with previous literature on the effects of foodborne disease outbreaks, food scares and government warnings, our results show that consumers do respond to outbreaks, at least temporarily. Moreover, not only did consumers reduce their purchases of affected products, they also did not switch to unaffected alternatives. As a result, overall egg purchases dropped. These findings have policy implications for consumers, producers, and policymakers. They show that consumers do respond to recalls and that these responses are an incentive for firms to invest in risk reduction and to comply with existing regulations. They also contribute to a discussion on the need for additional investments in food safety, product tracking, and the enforcement of existing regulations in order to improve the availability of safe products for consumers.

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For additional information, the authors recommend:

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Shimshack, J., M. Ward, and T. Beatty. "Mercury Advisories: Information, Education and Fish Consumption." *Journal of Environmental Economics and Management* 53(2) (2007): 158-179.

Demand Growth and Commodity Promotions for Fresh Hass Avocados

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Shipments of fresh Hass avocados to the U.S. have increased dramatically in recent years, primarily in response to the opening of the U.S. market to imports from Mexico. Inflation-adjusted prices received by California growers have nonetheless remained nearly constant on average, despite considerable year-to-year volatility. Our analysis shows that consumer demand growth, fueled in part by a successful industry promotion program, has prevented falling prices.

California avocado growers' long-standing program to fund advertising and promotion programs for their fruit was extended to include imports of fresh avocados through the Hass Avocado Promotion, Research, and Information Act, signed into law on October 23, 2000. Mandatory program assessments of 2.5 cents per pound on all Hass avocados sold in the U.S. market commenced effective January 2, 2003 under the Hass Avocado Promotion, Research and Information Order (HAPRIO).

The assessment is collected by first handlers for California production and by the U.S. Customs Service for imports and forwarded to the Hass Avocado Board (HAB). These funds are then allocated to programs and activities designed to increase the demand for Hass avocados in the U.S. market. The HAB uses 15% of the assessments to fund activities such as nutrition research, marketing, and information programs intended to benefit all avocado producers. It rebates 85% of domestic assessments to the California Avocado Commission (CAC) and up to 85% of importer assessments to the certified importer associations for their own promotion programs. There are currently three certified importer associations operating under the HAB: the Chilean Avocado Importers Association (CAIA), the Mexican Hass Avocado Importers Association (MHAIA), and the Peruvian Avocado Commission (PAC).

This article summarizes the evaluation of the economic impact of promotional expenditures conducted under HAB's auspices on U.S. demand for fresh avocados, and estimates producer returns from the expenditures for the second five years of the HAB's operations—the period from 2008 through 2012. We estimated an aggregate annual model of demand for fresh avocados in the United States. A market simulation model was constructed using results from estimation of the annual model and utilized to estimate benefits and costs from the promotion program.

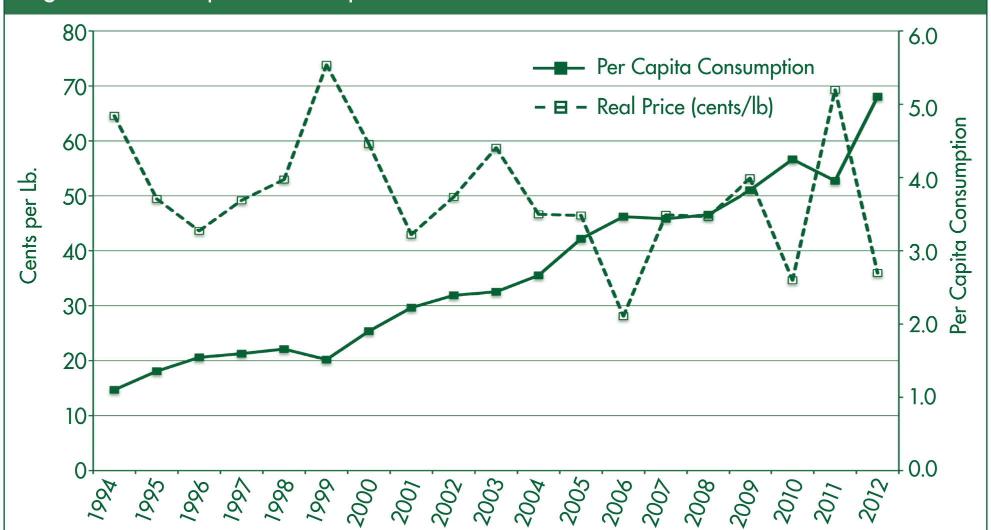
Supply and Demand of Avocados

Since HAB assessments to support avocado promotion began in 2003, avocado imports and total U.S. supplies (Hass and other varieties) have continued to increase to a record total of over 1.6 billion pounds in 2012. Mexican avocado exports to the U.S. increased significantly after Mexico gained year-round access to all states except California and Florida in 2005 and to all states in 2007. Mexican imports of 933.8 million pounds accounted for over 58% of the total U.S. supply of fresh avocados and for 86.7% of total fresh avocado imports in 2012. Market share for imports increased from 30% in 2000 to 67% in 2012.

The U.S. demand for avocados has grown substantially in the ten years since the HAB began funding promotional programs in January 2003. As shown in Figure 1, U.S. consumption has exceeded two pounds per capita annually since 2001, exceeding three pounds per capita in 2005, four pounds per capita in 2010, and five pounds per capita in 2012.

Figure 1 also depicts the average price per pound in real (inflation-adjusted, base year 1982-84) terms received by California growers for these same years. The farm-level demand for avocados is widely acknowledged to be quite price inelastic, with empirical estimates typically near -0.25. In the absence of substantial demand growth, one would have, thus, expected sharply lower prices to accompany an increase in avocado supply of over 200%. But, despite the real grower price

Figure 1. Per Capita Consumption and Real Producer Price for Fresh Avocados



Source: USDA, NASS

Table 1. U.S. Avocado Promotional Expenditures by Organization: 2003–2012

Year	CAC	CAIA	MHAIA	PAC	HAB	Total
			1,000 dollars			
2003	8,682	1,427	0	0	146	10,256
2004	10,756	3,010	700	0	859	15,325
2005	11,838	5,743	2,900	0	2,603	23,084
2006	10,499	2,661	4,500	0	2,562	20,222
2007	9,205	3,865	6,247	0	3,097	22,413
5-YR Sub-total	50,980	16,705	14,347	0	9,268	91,300
2008	10,470	3,819	7,141	0	3,102	24,532
2009	6,559	5,405	13,995	0	4,646	30,604
2010	8,780	2,351	13,379	0	5,908	30,418
2011	9,004	3,732	11,419	0	3,555	27,710
2012	11,632	1,994	17,713	952	4,220	36,510
5-YR Sub-total	46,444	17,301	63,647	952	21,430	149,774
Grand Total	**97,425**	**34,006**	**77,993**	**952**	**30,698**	**241,073**

exhibiting considerable year-to-year volatility (characteristic of a commodity with inelastic demand) it has, on average, remained stable over this time period, reflecting the substantial demand growth that has occurred.

Avocado Promotions

Initiation of assessments on all Hass avocados sold in the U.S. market in 2003 and increasing Hass avocado imports has significantly increased the availability of funds for promotion programs. Table 1 shows promotional expenditures by year for avocados from the U.S. (CAC), Chile (CAIA), Mexico (MHAIA), and Peru (PAC), plus promotional expenditures made by the HAB itself.

During the HAB's first five years of operation, 2003 through 2007, CAIA, MHAIA and HAB spent $40.32 million promoting avocados in addition to $50.98 million spent by California producers. Total CAC promotional expenditures for the next five years, 2008–2012, decreased just over 10% as a result of relatively small crops in 2009 and 2011. But promotional expenditures by HAB and country organizations financed by fresh avocado imports raised *average* avocado promotion from $18.26 million annually from 2003 to 2007 to $29.95 million annually from 2008 to 2012 (table 1).

Table 2. Annual Model Regression Results

	Model 1 (GLS)		Model 2 (GLS)		Model 3 (2SLS)		Model 4 (2SLS)	
Variable	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
California FOB Price (cents/lb.)	-0.012***	-3.67	-0.015***	-5.28	-0.011*	-1.64	-0.001	-0.20
Per Capita Income	0.276*	1.92	-0.287***	-3.62	-0.155*	-1.85		
Total Promotion	0.113***	4.18	0.049**	2.19	0.052***	2.48	0.077**	2.93
Time Trend			0.214***	8.17	0.180***	6.40	0.132***	7.46
Constant	-1.633	-0.71	5.279***	4.75	3.349**	2.33	0.754*	1.88
Durbin-Watson Statistic	1.310		1.465		-		-	
Observations	19		19		18		18	
Adjusted R^2	0.981		0.986		0.993		0.982	
Advertising Elasticity	0.354		0.153		0.163		0.241	

Promotion Evaluation

Carman, Li, and Sexton (CLS 2009) conducted the first evaluation of the HAB promotion programs for the five-year period from 2003 through 2007. CLS found that advertising and promotion funded under the HAB increased the demand for fresh avocados during the program's first five years of operation and yielded a favorable rate of return to avocado producers.

Annual Demand for Avocados

Economic theory posits that demand for a commodity is a function of that commodity's price, prices of goods that are used as substitutes or complements for the commodity, and consumer income. Successful promotions can also be an important factor in expanding demand for a product. We estimated annual per capita fresh avocado demand as a function of price, per capita income, a time trend, and total HAB and CAC promotions. The annual model analysis utilized data from 1994–2012. Table 2 contains the annual demand model results for four model specifications.

Model 1 in table 2 includes real f.o.b. price, real per capita income, and real promotion expenditures as explanatory variables. Model 2 adds a linear time trend, *YEAR*, to Model 1. Models 3 and 4 are adjusted to account for the fact that price and consumption are likely jointly determined. These models use U.S., Chilean, and Mexican avocado acreage as instrumental variables (i.e., a proxy) for price. Real promotion expenditures represent the key variable of interest in all 4 models.

In all cases, promotion expenditures have a statistically significant and positive impact on per capita U.S.

avocado consumption. The estimated coefficients for promotion expenditures range from 0.049 (model 2) to 0.113 (model 1). Models 3 and 4, which have the best statistical properties among the models, yield intermediate values for the promotion coefficient of 0.052 and 0.077, depending upon whether per capita income is included in the model.

Because the magnitude of the estimated coefficients depends upon the choice of units to measure the model variables, it is desirable to convert the coefficients to elasticities, which measure estimated percentage impacts and, thus, are unitless. The estimated promotion elasticities evaluated at the data means range from 0.153 (model 2) to 0.354 (model 1) (see table 2).

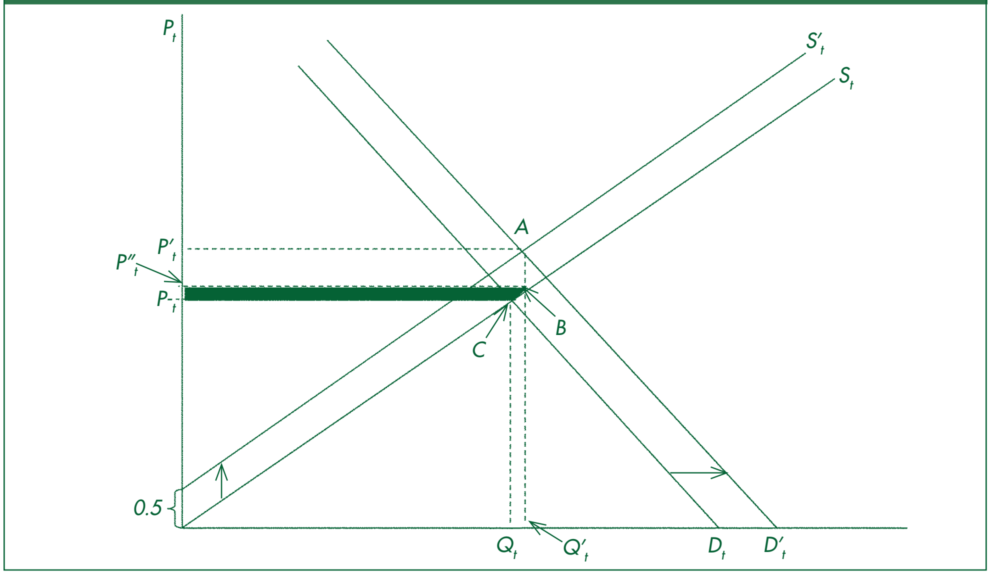
The other variables included in the model perform much as economic theory would predict and estimates are also consistent with prior work. The one exception is the impact of the income variable when it is included in a model with the time trend. These two variables are highly correlated and, in essence, it is impossible to isolate the unique impacts of growth in consumers' incomes on avocado consumption from other economic factors that are captured in the trend term.

Cost-Benefit Analysis of Promotional Expenditures

The annual demand analysis presents strong evidence that generic promotion of fresh avocados has worked to increase the demand for fresh avocados in the United States. The additional question to ask, however, is whether the expenditures have "paid off" in the sense of yielding benefits to producers from the demand enhancement that exceed the money expended to fund the programs.

The average benefit-cost ratio (ABCR) from a promotion program consists of the total incremental profit to producers generated by the program over a specified time period divided by the total incremental costs borne by producers to fund a program. The ABCR is the key measure of whether a program was successful, with ABCR > 1.0 defining a successful program.

Figure 2. Avocado Promotion Simulation Model



The marginal benefit-cost ratio (MBCR) measures the incremental profit to producers generated from a small expansion or contraction of a promotion program. MBCR answers the question of whether expansion of the promotion program would have increased producer profits, with MBCR $\geq$ 1.0 indicating a program that could have been profitably expanded.

Substantial diagnostic tests performed by CLS (2009) in their evaluation of avocado promotion supported use of a linear demand model, which we thus also utilized. For the linear model ABCR = MBCR, and the two questions "was the program profitable" and "could it have been profitably expanded" are one and the same.

Our strategy in estimating ABCR and MBCR for the promotion programs conducted under HAB's auspices was to simulate the impact of a small hypothetical increase in the HAB assessment rate from the current level of \$0.025/lb. to \$0.03/lb., i.e., an increase of one-half cent per pound, and estimate the benefits and costs to avocado growers from that assessment expansion based upon the results of the annual demand analysis.

The simulation framework is depicted in figure 2. The model begins with demand and supply functions for avocados that depict the U.S. market for a given year *t*. Thus, demand, D_t, is total U.S. demand in year *t*, on a per capita basis. Supply, S_t, is total supply to the U.S. market in year *t* from all sources. Under the current program, total U.S. consumption in year *t*, given functions S_t and D_t, is Q_t, and grower price is P_t. Implementation of a one-half cent per pound expansion in the program assessment increases producer costs per pound by that half cent, S'_t as depicted in figure 2.

The hypothetical increase in assessment generates incremental funds for promotions equal to the change in assessment multiplied by total shipments to the U.S. market. The marginal impact of the additional promotional expenditure on demand is determined by the regression coefficient for the promotion variable, which is reported for alternative model specifications in table 2.

The new demand curve is illustrated in figure 2 by D'_t. The new market equilibrium is found at the intersection of curves S'_t and D'_t at point A in figure 2. Thus, the model predicts that equilibrium price in year t would have risen to P'_t and sales have risen to Q'_t with the incremental assessment.

Producer benefits from the hypothetical expansion of the promotion program are measured in terms of the change in producer surplus (PS). PS is the same as producer variable profits, namely revenue (producer price *x* output) minus the variable production costs associated with producing and selling the output.

We seek to measure the change in PS associated with the hypothetical expansion of the promotion program. In figure 2, PS after the program expansion is $PS' = P'_t \times Q'_t - 0BQ'_t$, but we must also account for the additional promotion expenditure, which is represented geometrically by the rectangle $P'tP''_t AB = (P'_t - P''_t)Q'_t$. Thus, the net increase in PS to producers from expansion of the promotion program is $\Delta PS = PS' - (P'_t - P''_t)\, Q'_t$, which is represented by the shaded area in figure 2.

Information required to estimate ΔPS consists of: (i) an estimate of the marginal impact of promotional expenditures on demand, (ii) an estimate of the slope or price elasticity, $\in_D$, of the grower-level demand curve, and (iii) an estimate of the slope or price elasticity, $\in_S$, of grower supply of avocados to the U.S. market. The results of the econometric estimates reported in table 2 provide estimates of (i) and (ii).

We evaluated these considerations, and specified three alternative values, 0.5, 1.0, and 2.0, as representing a plausible range of values for $\in_S$. Among the demand models included in table 2, we selected models 1 and 3 for use in the simulation. Benefits and costs were estimated for each of the five years, 2008–2012, under evaluation.

The model was implemented by fitting the demand and supply functions to the actual values observed for the real grower price and per capita consumption for each year of the review period. S_t was then shifted vertically to S'_t by the half-cent incremental assessment for each year, and D_t was shifted horizontally to D'_t by the estimated promotion coefficient times the funds generated by the incremental assessment, producing the equilibrium at point A in figure 2 and enabling us to compute the hypothetical changes in P and Q and the ΔPS.

Total net producer benefits are reported for each model by compounding the annual benefits and costs over the five-year period to 2012, using a 3% real rate of interest. The estimated benefit-cost ratios in this study range from 2.12 to 9.28. The lower bound is associated with model 3, which has a small coefficient for promotion relative to model 1, and the most elastic supply response, $\in_S=2.0$. The average annual increase in the grower price due to promotions for this simulation is 2.6%. The upper bound of 9.28 is associated with demand model 1, which has a high coefficient for promotion, and with the most inelastic supply response, $\in_S=0.5$. The average annual price increase for this simulation is 12.3%.

Space considerations preclude us from discussing results of the disaggregate model estimated using scanner data. Those results are available upon request from the authors and showed a statistically significant positive impact of promotions on weekly sales in those market areas receiving promotions through the HAB, thus reinforcing the results from the annual model.

Conclusion

Fresh avocados have seen remarkable growth in consumption per capita in the U.S., rising from about 1.5 pounds during the decade of the 1990s to over 5 pounds in 2012. This rapid increase in imports to the U.S. and commensurate consumption has been achieved while keeping real grower prices relatively constant on average over this time period. Such an outcome is only possible with substantial growth in fresh avocado demand in the U.S. over this time.

The econometric analysis of annual fresh avocado demand conducted in this study provides strong statistical evidence of this demand growth and support for the proposition that promotion expenditures have been an important causal factor. Benefit-cost analysis conducted based upon these econometric estimates yielded estimated average and marginal benefit-cost ratios in the range of 2.12 to 9.28. We conclude with considerable confidence that the promotion programs conducted under the HAB's auspices have been successful in both expanding demand for fresh avocados in the U.S. and yielding a very favorable return to those funding the program.

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China's Growing Role in Agricultural Trade

Colin A. Carter and Sandro Steinbach

This article discusses developments in China's agricultural trade and implications for the United States. We highlight areas in which China has become a major exporter of agricultural products, the global importance of these exports, and factors that underlie the export trends. In addition, we reference market access issues faced by China's agricultural exports.

China produces over 20% of the world's cereal grains, 25% of the world's meat, and 50% of the world's vegetables. China is the world's largest agricultural economy, and it ranks as the top global producer of pork, wheat, rice, tea, cotton, tomatoes, potatoes, eggs, wool, apples, walnuts, and fish, etc. In fact, the annual value of China's agricultural output is about two and one-half times the U.S. total.

After joining the World Trade Organization (WTO) in 2001, China increased its trade dependence on agriculture. As of 2011, it was the fourth largest exporter and second largest importer of agricultural products in the world, according to WTO trade statistics. Its import growth has been driven by a shift in its domestic production mix, and changing consumer diets with rising incomes and urbanization. China's substantial increase in fruit and vegetable production is a major factor behind it agricultural export growth.

In agriculture, China's major policy objectives are focused on increasing grain production and starting the transition to larger-scale farms. China has a relatively low set of agricultural import tariffs compared to other WTO members and domestic support to agriculture in China remains less than that for many developed countries.

Changing Trade Structure

With imports growing faster than exports during the post-WTO accession years, China reversed its longtime status as a net agricultural exporter to that of a net importing country since 2004. Most of China's increased imports came from soybeans and cotton. Today cotton and soybeans account for over 40% of China's agricultural imports, a very concentrated portfolio. China is the world's largest importer of soybeans and cotton, accounting for over 60% of global soybean imports and approximately 40% of cotton imports.

It was expected that China's production and trade of agricultural products would be significantly affected by WTO entry and this has turned out to be the case. China's agricultural exports have increased by more than 12% annually. Import growth has averaged 19% per annum, while total agricultural trade has grown by more than 16% per annum from 2002 to 2011. These are truly impressive annual growth rates.

The changing structure of China's agricultural exports has been dominated by very strong growth in exports of horticultural products (e.g., garlic, apples, pears, and citrus), semi-processed food products (e.g., animal products, pet food), and aquaculture (e.g., fish fillets). Table 1 shows the annual growth in exports for various agricultural categories from 2001-2011. From top to bottom, the annual growth rate was 18% for horticultural exports, 14% for semi-processed foods, 13% for aquaculture, 12% for processed (e.g., apple juice, processed tomatoes), and less than 2% for bulk items such as tea or tobacco.

Regarding accomplishments in world markets, China's exports of aquaculture products have grown from 8% of the world market in 2001 to 14% of the market in 2011—a remarkable achievement. China is very successful at exporting frozen fish fillets of various types, including salmon. There is a large fish processing industry in China that imports whole salmon and other fish from the U.S., Russia, and elsewhere and then, in turn, re-exports fish fillets. Another category that is also a strong export performer is horticultural products, rising from 2.5% to 5.6% of world exports, more than doubling its market share.

China's trade patterns have been affected by concerns over food safety with some food products. For instance, the melamine-spiked milk scandal of 2008 has led to a surge in China's imports of milk powder—China's skim milk powder imports were up about 50% just in the past year, contributing to higher milk powder prices in world

Table 1. Annual Growth Rates of China's Agricultural Exports Since WTO Accession

	Aquaculture	Bulk	Processed	Horticulture	Semi-Processed
2001–2011 Annual Growth Rate in Value of Exports	13.3%	1.7%	12.2%	18.0%	14.5%

Source: Compiled from UN COMTRADE data

Table 2. Export and Import Trade Growth Rate of China's Labor-Intensive Agricultural Products, 2001–2011

	Aquaculture	Livestock	Horticulture
Exports	13.3%	7.7%	18.0%
Imports	13.5%	15.8%	21.0%

Source: Compiled from UN COMTRADE data.

markets. China is responding to the food safety issue and has reorganized its food safety regulatory system, modeled on the FDA in the United States.

China's agricultural trade is more and more in line with its comparative advantage and it has noticeably increased imports of land-intensive agricultural products. But what about its trade in labor-intensive products? Although exports of labor-intensive agricultural products did increase quite fast after WTO accession (especially for fruits and vegetables), the rate of increase for these years was lower than imports of land-intensive agricultural products. For instance, the annual export growth rate for labor-intensive fruits and vegetables was 22% and 16.7%, respectively. At the same time, imports of land-intensive soybeans and cotton grew by 25% and 35.7%, respectively.

Surprisingly, the import growth of labor-intensive agricultural products was also quite high—in fact, greater than the export growth rate of these products for the same period. Aquacultural exports grew by 13.3%, slightly less than its import growth of 13.5%. Horticultural exports grew by an impressive 18% per annum, but horticultural imports grew even faster at 21% per annum (Table 2).

So what do all these numbers suggest regarding China's trade? First, land-intensive imports are growing faster than labor-intensive exports. Second, for labor-intensive products, imports are actually growing faster than exports. There are three likely factors behind these trends. First, there is growing domestic demand for high-valued agricultural products including labor-intensive imports, increasing with income and urbanization. Second, China's agricultural labor is shifting away from agriculture to the higher paying manufacturing and service sectors. Third, China's labor-intensive agricultural exports face headwinds in world markets due to trade barriers and perceptions of poor quality.

China-U.S. Agricultural Trade

The United States enjoys an agricultural trade surplus with China, which exceeded $20 billion in 2012. This is partly a result of reduced import trade barriers in China, and growing incomes and urbanization. China is the most important market for U.S. agricultural exports (accounting for 17.2% of U.S. agricultural exports in 2012) and the third most important supplier of U.S. agricultural imports (with a market share equal to 4.2% of U.S. agricultural imports in 2012).

Table 3 shows that based on the value of trade, the top five U.S. agricultural exports to China (in order of importance) are soybeans, cotton, corn, hides/skins, and swine offal. On the other hand, the top five U.S. imports from China are apple juice, dog and cat food, frozen tilapia fillets, canned citrus, and frozen salmon fillets. It is notable that the sum total of China's agricultural exports to the United States represents only two-thirds of the value of just one single item that the United States sells to China—soybeans.

China is an emerging competitor for U.S. farmers in some specialty crops, and China has a positive trade balance with the United States on horticultural crops, although the total dollar value is a relatively small share of total agricultural trade. Figure 1 shows China had a trade surplus of $40 million in horticultural products with the United States in 2011, down from $157 million in China's favor in 2007. The 2011 $40 million surplus is only 1% of the value of agricultural trade between the United States and China. China's growing demand for almonds, pistachios, and walnuts is a positive development for U.S. agriculture. And per capita consumption of these specialty crops is still very low in China. For instance, per capita consumption of almonds in China is only about 5% of the U.S. figure.

U.S. food products enjoy a certain advantage in China and there are growing opportunities for U.S. products, considered to be high quality. However, price remains an obstacle for U.S. products in the China market. Chinese consumers spend about 20%

Table 3. Major U.S.–China Agricultural Products Traded Bilaterally in 2012

U.S. Exports to China		U.S. Imports from China	
Item	Value (Mil.)	Item	Value (Mil.)
Soybeans	$15,374	Apple Juice	$561
Cotton	$3,686	Dog and Cat Food	$467
Corn	$1,658	Frozen Tilapia Fillets	$444
Hides and Skins	$1,219	Canned Citrus	$233
Frozen Swine Offal	$744	Frozen Salmon Fillets	$216

Source: USDA FAS GAIN Report 2/25/2013, based on China Customs Data of their disposable income on food consumed at home, compared to less than 7% of income spent on at-home food in the U.S., on average.

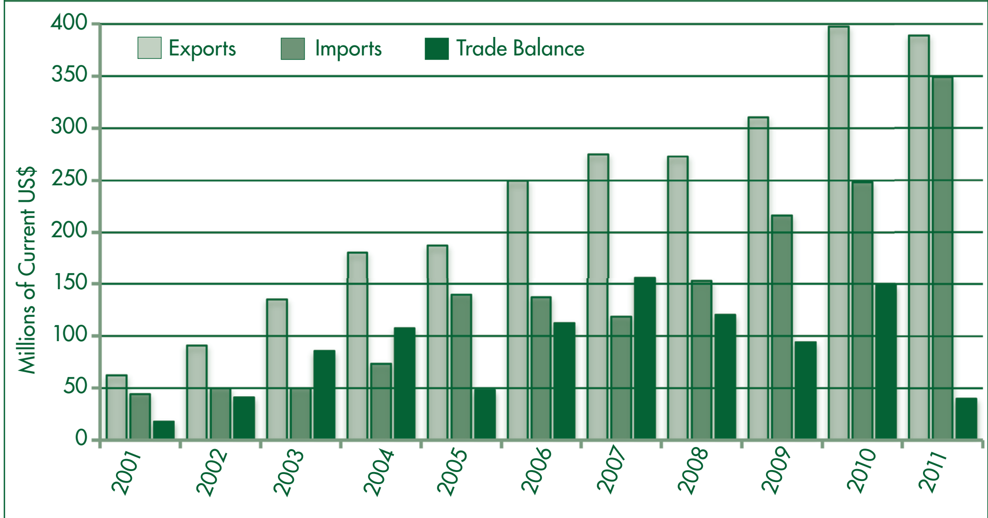
Impediments to China's Exports

Impediments to foreign market access are an issue for Chinese agribusiness firms. For instance, China's agricultural exports of horticultural products have been adversely affected by anti-dumping (AD) investigations against them, launched by firms in both developing and developed countries. Globally, there have been about 23 AD cases against China's agriculture since that market opened up in the early 1980s, and many of the AD actions in agriculture have targeted horticultural products—resulting in very high tariff rates against Chinese exports.

Most anti-dumping cases are nothing more than hidden protectionism. Under U.S. AD law, China is treated as a "non-market economy" and, as a result, its exporters have been assessed tariffs higher than typical AD rates applied to so-called market economies. U.S. AD cases against China's exports have targeted imports of fresh garlic, preserved mushrooms, apple juice concentrate, shrimp, and crawfish tail meat. With the exceptions of honey and shrimp, these cases have had mixed success at keeping out Chinese exports for more than a few years.

But in each and every case, the U.S. consumer has paid higher prices as a result of the dumping orders. Honey from China has clearly been kept out. China's share of U.S. honey imports was around 30% when the AD case was initiated in 2000, and today that market share is near zero. Instead, the U.S. imports honey from India, a higher-cost supplier. This is called trade diversion, good for the honey industry in India and the United States, but costly for U.S. consumers.

Figure 1. China's Trade Balance with the U.S. in Horticulture



Source: Compiled from UN COMTRADE data

Conclusion

After more than a decade following WTO accession, the value of China's agricultural trade has increased dramatically and China has turned into a net importer of agricultural products and now ranks as the number one foreign market for U.S. agriculture. Although considerable resource shifts have taken place from land-intensive towards labor-intensive agricultural products in both production and trade, this transfer remains well below the potential. This is partly due to trade barriers facing China's exports of labor-intensive agricultural products.

Food, animal, and plant safety are rightfully a concern of importing countries, but have unfortunately been used, like AD, for protectionist purposes. There is considerable interest in the impacts of China's rising income growth, a growing middle class and urbanization, and the associated changes in dietary patterns and food imports. These variables will only fully come into play if China's trading partners are willing to recognize that international trade is a two-way street.

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For additional information, the authors recommend:

http://dimsums.blogspot.com/

www.uscc.gov/Hearings/hearing-china's-agricultural-policy-and-us-access-china's-market

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