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Is Dust "Busting" Crop Yields?

Maximilian Auffhammer

We have long known that air pollution has a negative effect on plant growth. Dust deposits on leaves and higher ozone concentrations in fields result in smaller plants for many crops. Recent research on local climate change has shown that a class of air pollutants, called "aerosols," may have a local drying and cooling effect. While cooler nights are good for many plants, these gains are possibly offset by decreased rainfall and solar radiation.

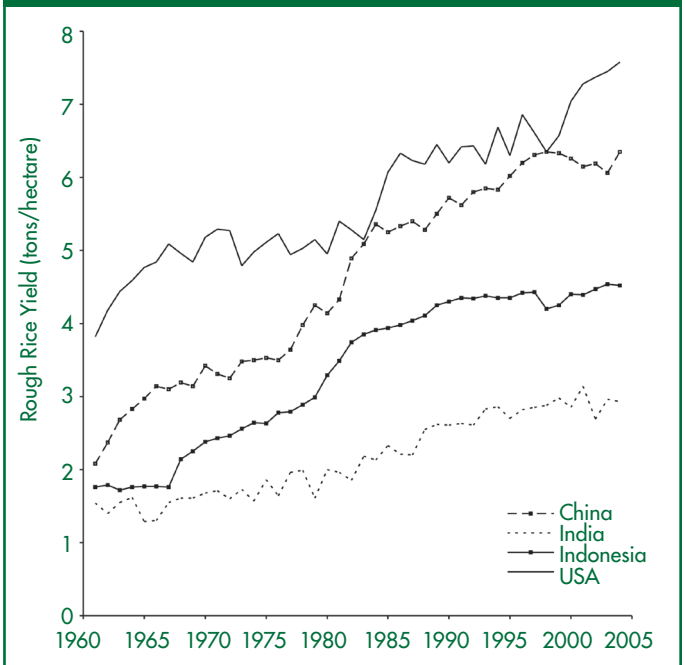
Rice is the staple food grain for over two billion people in Asia alone, who derive 60-70 percent of their caloric intake from the grain and its derivatives. It is also the most rapidly growing source of food in Africa. According to the United Nations Food and Agriculture Organization, rice production and processing employs over one billion people in the developing world alone. They identify declining yield growth rates, natural resource depletion, labor shortages, gender issues, institutional limitations, and environmental pollution as the main threats to global rice production.

As Figure 1 shows, yields in China, India, and Indonesia grew rapidly during the 1960s and 1970s. Most of this growth was due to the Green Revolution, which introduced hybrid varieties, irrigation, fertilizers, and pesticides to the developing country rice-production system. During the 1980s and continuing until present day, however, yield growth started to slow down and has recently leveled off. Explanations for the deceleration include sharply lower rice prices, deterioration of irrigation infrastructure, soil degradation due to the mismanagement of water and chemical inputs, stagnant technology on rain-fed farms, and reaching the technological frontier on irrigated farms. Ongoing work by UC researchers and their collaborators is examining the role of another possible culprit: air pollution.

The Asian Haze

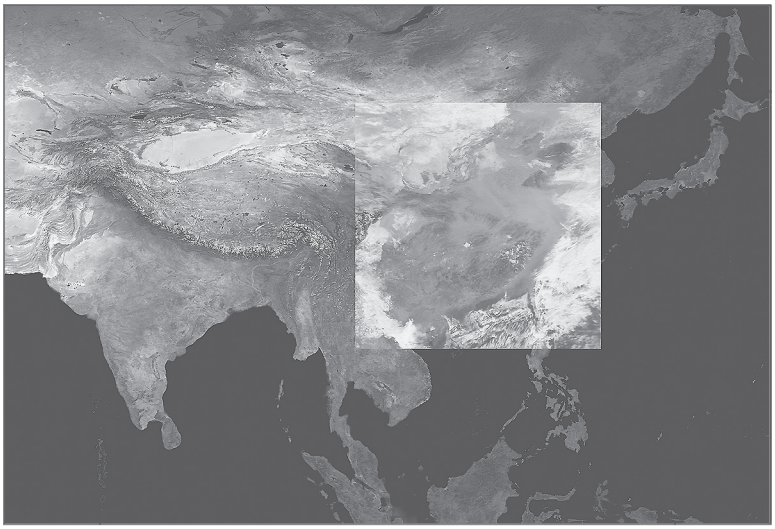
Regional impacts of global warming hinge on the potentially sizeable cooling effect of a pollutant known as aerosols. These small particles, which measure about a millionth of a centimeter in diameter, reflect sunlight back into space and cause a local cooling effect at ground level.

Figure 1. U.S. and Asian Rice Yields 1960 2004



Source: IRRI World Rice Statistics (2006)

Also in this issue



Biomass burning and fossil fuel combustion are major sources of the haze.
Photo Credit: NASA

This class of pollutant is made up of various components, including sulfates, soot, organic carbon, and mineral dust. A large number of global warming models show that this cooling is one of the largest, if not the largest, source of uncertainty in predicting future climate at a regional scale. Field experiments, such as the Indian Ocean Experiment (INDOEX), have been undertaken to collect geographically specific data on the regional cooling effect of sulfates and other aerosols.

The INDOEX experiment led to the Atmospheric Brown Cloud (ABC) Project, chaired by UC San Diego Professor, V. Ramanathan, which is a multidisciplinary effort to study the aerosol layer known as the Indo-Asian haze, its impacts on local climate, and its socioeconomic consequences. The Indo-Asian haze covers most of South Asia and a substantial portion of the Indian Ocean from roughly November to May. Biomass burning and fossil fuel combustion are major sources of the haze. The region is home to much of the world's population and is experiencing rapid industrial and demographic growth. It is vulnerable to unexpected negative impacts from the haze on health, the hydrological cycle, and agriculture. Existing studies on the impacts of global climate change on Asian agriculture have taken into account the impact of warming on the hydrological cycle, water budget, and fertilization from additional CO_2. The predicted decrease in yields from warming, due to global climate change, averaged over the Asian region range from 15-30 percent by the year 2050. These studies have, however, not taken into account the potential direct and indirect impacts from the haze.

Impacts on Local Climate

The negative impacts of local air pollutants on human health have been extensively studied and have motivated regulation on a local, regional, national, and global level. The most widely discussed of these pollutants, ozone, also has direct negative impacts on plant growth. Laboratory experiments using open-top chambers have shown that 50 parts per billion (ppb) concentrations of ozone decrease yields of winter wheat by 10 percent and rice by eight percent. A doubling of this concentration, which is 20 ppb below the hourly federal standard set by U.S. Clean Air Act, leads to decreases of yields by 59 percent and 26 percent, respectively. Other pollutants which make up the haze, such as soot, dust, and fly ash, can settle on plant leaves and shield pollutants from solar radiation. These deposits interfere with the plant's ability to conduct photosynthesis and may cause localized warming on the plant. Further, through the acidity of the haze, it causes or augments negative consequences from acid rain on soil chemistry and plant tissues.

These direct effects of air pollution ignore the recently discovered interaction between the haze and local climate. In addition to the direct effects mentioned above, the haze can in theory affect agricultural production indirectly through three main pathways. The first is the reduction of sunlight available to crops. Aerosols increase the reflection of solar radiation back to space and, in addition, increase absorption of solar radiation in the atmosphere. The absorption and scattering of solar radiation lead to a large reduction of direct sunlight available to plants. The reduction of solar radiation due to the haze at the surface is estimated to be approximately 10 percent. The second indirect effect is the suppression of rainfall by haze. The presence of aerosols results in more clouds, which contain smaller droplets and are less likely to release rain. The cloud drops in turn further scatter solar radiation and cause additional dimming. The estimated rainfall reductions due to ABCs during monsoon season range from five to eight percent annually relative to the 1930-1960 average. The climate models further forecast an increased frequency of droughts. The final indirect effect of the haze is a local surface cooling, which is strongest during the months between October and May.

Estimating Impacts on Agriculture

There are numerous studies which attempt to estimate the impacts of changes in solar radiation, temperature, and rainfall on crop yields. Researchers either use data from experimental plots, where crops are grown under optimal conditions, and then artificially apply some stress to the plants—such as less solar radiation or water—to estimate impacts on yields. An alternate

approach is to use computerized crop simulation models to estimate the impact of these stresses on yields and plant growth. For both methods, one attempts to apply all necessary inputs optimally and then increases or decreases the stress factor. While these models ignore the farmer's reaction to changes in environmental variables by switching crops or planting different varieties, they provide a first-order estimate of the impacts from environmental stresses.

A recent study published in the Proceedings of the National Academy of Sciences, estimates the impact on rice yields from changes in nighttime temperatures and solar radiation. Using weather and yield data from an experimental farm in Los Banos (Philippines) over the period 1979 to 2003, the authors show that a 1^0C increase in minimum temperature would result in a 10 percent decrease in grain yields during the growing season. Crop simulation studies have estimated a similar impact. Since aerosols cause a local cooling, this may seem like good news for irrigated agriculture. Unfortunately this may not be so. The same study shows a strong positive relationship between grain yield and solar radiation during low-radiation months, which is the case during monsoon season. Although the mechanisms are not yet well understood, a lower amount of solar radiation received by the plant during the grain-filling stage is one possible mechanism through which the haze may affect crop yields.

The immediate impact on irrigated rice yields through reductions in rainfall are likely small in the short run, since farmers can substitute by pumping more groundwater. For non-irrigated rice farming, the reductions in rainfall are likely to have larger consequences since farmers do not have this ability to substitute. This is a major concern for small subsistence farms.

The California Energy Commission has sponsored an ongoing research project, which attempts to quantify the impacts of anthropogenic aerosols on California climate. Preliminary results suggest a reduction in precipitation in the Sierra-Nevada Mountains and the Central Valley in February and August. Further, simulations suggest decreased ground temperatures and solar radiation in both months. The high concentrations of aerosols in many of the rural agricultural areas in the United States certainly warrant further examination of this phenomenon on crop yields in the U.S., which is a question currently under study at UC Berkeley's ARE department.

Los Angeles Haze Photo Credit: Ramanathan, 2003.

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For additional information, the author suggests the following sources:

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ARE Faculty Profile: Aaron Smith

Aaron D. Smith
Assistant Professor
Agricultural and Resource Economics
UC Davis

Since 2001, Aaron Smith has held a position as an assistant professor in the Department of Agricultural and Resource Economics at UC Davis. Prior to coming to Davis, Aaron earned a Ph.D. in Economics from UC San Diego and taught at the University of Virginia and UC Santa Barbara. He grew up in New Zealand, where his family operates a sheep farm.

Professor Smith's research addresses price behavior in commodity markets, including cotton, corn, natural gas, crude oil, and electricity. In addition, he works on developing new statistical methods for predicting and understanding the dynamic behavior of commodity prices and other economic variables.

In one line of research, Aaron studies the nature of price fluctuations in commodity futures markets. Futures contracts enable the purchase or sale of a commodity at a fixed price at a fixed location in a particular month in the future. In research on the corn and cotton markets, Aaron shows that futures prices become excessively volatile as the delivery date approaches. This phenomenon arises because only a limited amount of the commodity is available for trade near the delivery location, and it is very expensive to transport the commodity from out of state at short notice. Therefore, when using futures markets to reduce price risk, agricultural producers should avoid futures contracts that are close to the delivery date. With Hiroaki Suenaga, a UC Davis Ph.D. graduate, and Jeffrey Williams of UC Davis, Professor Smith is conducting similar studies of futures markets for natural gas, crude oil, and gasoline.

With Colin Carter of UC Davis, Aaron studied the market impact of a prominent food scare. In 2000, a genetically modified corn variety called StarLink, that was not approved for human consumption, was discovered in the food-corn supply. Smith and Carter showed that this contamination event led to a 6.8 percent discount in corn prices and that the suppression of prices lasted for at least a year. The StarLink case continues to surface around the world as an example of policy error in managing biotechnology adoption.

In collaboration with a UC Davis Ph.D. graduate, Konstantinos Metaxoglou, Smith showed that the California electricity reserves market operated inefficiently before, during, and after the 2001 electricity crisis. The reserves market ensures the availability of extra generating capacity in case of unexpected spikes in electricity demand, and it operates separately from the market for electricity itself. In the reserves market, generators offer to keep their spare capacity on standby in case it is needed. They offer this standby capacity in two separate hourly auctions: one, a day ahead, and the other, an hour ahead of the delivery hour. Aaron and Konstantinos showed that utilities were forced to procure most of their standby capacity in the day-ahead market rather than the hour-ahead market, even though the day-ahead prices averaged 35 percent higher. This outcome raised the costs to utilities, and ultimately consumers, by hundreds of millions of dollars between 1999 and 2002.

Aaron lives in Walnut Creek with his wife, Heather Rose, who works as a research economist at the Public Policy Institute of California in San Francisco. When Smith is not tackling economic data, he spends his time tackling large human beings on the rugby field. As a New Zealander, he has played rugby since he was young and sees it as a natural part of life. For the last five seasons, he has played in the USA Rugby Super League for the San Francisco Golden Gate club. However, the fifth season may have been his last—he claims he's now too old to keep up.

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Retailer Pricing Practices for Fresh Avocados

Lan Li, Hoy F. Carman and Richard J. Sexton

Retailers' pricing practices for Hass avocados depart considerably from the behavior predicted by a model of competitive pricing. Retail prices within a market area exhibit considerable heterogeneity and little correlation with the farm price. Further, only about a third of farm price changes are transmitted to consumers. Retail prices for avocados tend to be lower during peak-demand periods. Finally, evidence suggests that outdoor and radio promotions by the California Avocado Commission have been effective in raising demand for avocados in the cities where the campaigns have been conducted.

Monthly demand for avocados varies seasonally. Demand is high during the summer months, May through September, with June having the highest monthly demand.

Photo Credit: UC Regents

Retailers are becoming the dominant player in the food distribution networks of the United States and other countries as a result of continuing growth and consolidation. While market power in the retail food sector is a fact of life, detailed information on the use of this power is not. Understanding pricing behavior is an important factor in assessing retailer market power. In addition, retailers' pricing practices for fresh produce are a critically important determinant of producers' and handlers' incomes. This article presents results on retailers' pricing practices for fresh avocados in the United States.

The characteristics of fresh avocados and many other produce items are important in pricing decisions and in the results of these decisions. Production is seasonal, as is demand, avocados are perishable and can only be stored for short periods, weather can cause supply shocks, industry promotion is concentrated in particular markets and at particular times, and imports have been increasing significantly over time. A few large retailers are buying from many smaller handlers/growers and in markets that are separated in time and space, considerations that suggest the opportunity for retailers to exercise market power in procurement of avocados. We focus on how retailers adjust avocado prices in response to changes in demand and cost factors, especially producer-sponsored promotion programs and seasonal demand cycles, and how these adjustments impact retail margins. We were particularly interested in the reactions of retailers to industry promotions.

The Data and Analysis

The California Avocado Commission (CAC) provided access to a unique micro-level dataset that included weekly retailer-scanner data for 82 major U.S. retail accounts across 38 markets for avocados from November 1998 to October 2004. The CAC also provided weekly shipment data, including shipping-point prices and shipment volumes of Hass avocados from California to each of the 38 destination markets during the study period. These data were supplemented with monthly import data from the United States International Trade Commission. Finally, we obtained information on the media types, geographic locations, and the timing of the CAC's advertising programs during the study period.

The full data set pools retail accounts, large and small avocados, and all time periods, generating 19,072 observations in total. There are 124 account-size combinations with 140 to 157 weeks for each account-size combination. The sample averages for the retail price of Hass avocados and the shipping point—retail-price spread were $1.30 and $0.73 per unit, respectively. A retail-pricing model was estimated to examine how retail prices vary in response to changes in cost and demand variables, such as contemporaneous and lagged shipping-point prices. Retail prices had a statistically significant positive correlation with the contemporaneous shipping-point price and its one period lag. The coefficients, however, indicate that only about 34 percent of a change in shipping-point price per unit is transmitted to the retail price

Table 1. Descriptive Statistics of Retail Prices and Shipping-Point Prices for Hass Avocados for Los Angeles Retails Chains

			—Price Ranges—				—Price Ranges—	
	Mean	Std. Dev.	25-75 pct.	Min-Max	Mean	Std. Dev.	25-75 pct.	Min-Max
	Panel (a) Retail Prices							
Account	Large Size				Small Size			
Los Angeles 1	1.70	0.48	0.58	2.48	1.14	0.34	0.44	2.02
Los Angeles 2	1.33	0.33	0.28	1.64	0.50	0.16	0.19	0.88
Los Angeles 3	1.87	0.22	0.18	1.30	0.68	0.22	0.42	1.18
Los Angeles 4	1.33	0.27	0.43	1.25	–	–	–	–
Los Angeles 5	1.66	0.36	0.61	1.51	1.16	0.28	0.50	1.12
	Panel (b) Shipping-Point Prices							
Market	Large Size				Small Size			
Los Angeles	0.72	0.15	0.16	0.72	0.37	0.08	0.12	0.50

within the two-week period. The partial response of retail prices to cost changes at the shipper level is a key indicator of retailer market power being exercised in the pricing decision.

The estimated coefficient of shipment volumes in the model of shipper-retail price spreads indicates that the retail markup increased significantly, by $0.04 per unit, when weekly shipments to a market increased by one million units. This result is consistent with prior work conducted at UC Davis that found retailers paid lower prices to grower-shippers when there was a larger supply of a perishable commodity, while maintaining retail prices and enjoying a larger profit margin. Competitive or "price-taking" retailers would be unable to capture larger margins in these settings, so this result is also consistent with retailers exercising market power over grower-shippers in procurement of avocados.

The data also reveal considerable heterogeneity among retailers in their pricing decisions for Hass avocados. Tables 1 and 2 illustrate this point for retail chains in the Los Angeles area. Table 1 provides mean prices, standard deviation of prices, range in price for the 25th and 75th percentile observations, and range between minimum and maximum price for both large and small Hass avocados for five Los Angeles chains. Acquisition and transportation costs for these chains should be very similar; yet we see that average prices vary considerably among the chains, especially for small avocados, as does the variability of prices, as measured by the standard deviation and the price ranges. Note that the variability of retail prices is much higher than variability of the shipping-point prices for the Los Angeles market.

Table 2 presents correlations between the retail prices for Hass avocados set by the chains and between retail prices and shipping-point prices—both in the current period and lagged one period (–1). Recall that correlation coefficients range from –1.0 to 1.0, with negative correlations indicating movements of prices in opposite directions, correlations near zero indicating little or no relationship in price movements, and positive correlations indicating prices that move together.

Because acquisition costs for Hass avocados must be very similar among Los Angeles retailers, we would expect to see high correlations among the retail prices and between retail and shipping-point prices if retailers are pricing avocados competitively by imposing a markup to acquisition costs that is based upon their selling costs. Instead, however, we see that the correlations of retail prices are in general near zero and in some cases are negative. Further, correlations of retail prices with the shipping-point prices, whether contemporaneous or lagged one period, are also near zero, indicating that changes in the

Table 2. Price Correlations for Hass Avocados for Los Angeles Retail Chains

	LA-1 Large	LA-1 Small	LA-2 Large	LA-2 Small	LA-3 Large	LA-3 Small	LA-4 Large	LA-5 Large	LA-5 Small
LA-1-Large	1.00								
LA-1-Small	0.53	1.00							
LA-2-Large	0.31	0.16	1.00						
LA-2-Small	0.09	0.11	0.19	1.00					
LA-3-Large	0.12	0.32	0.16	0.01	1.00				
LA-3-Small	–0.09	0.30	0.04	0.35	0.33	1.00			
LA-4-Large	–0.20	0.32	0.43	0.09	0.17	–0.05	1.00		
LA-5-Large	0.51	0.55	0.31	0.24	0.22	0.38	0.34	1.00	
LA-5-Small	0.31	–0.15	0.23	0.02	0.08	–0.26	0.25	0.04	1.00
Shipping Point-Large	0.13	0.27	0.13	0.34	0.14	0.13	0.36	0.35	0.32
Shipping Point-Large(–1)	0.16	0.29	0.15	0.33	0.17	0.15	0.34	0.35	0.31
Shipping Point-Small	0.28	0.35	0.26	0.45	0.10	0.16	0.40	0.43	0.35
Shipping Point-small(–1)	0.28	0.38	0.27	0.48	0.12	0.18	0.34	0.44	0.33

shipping-point price have little effect on prices charged at retail. On balance, our results indicate that procurement costs are not a primary factor in determining retail prices for avocados.

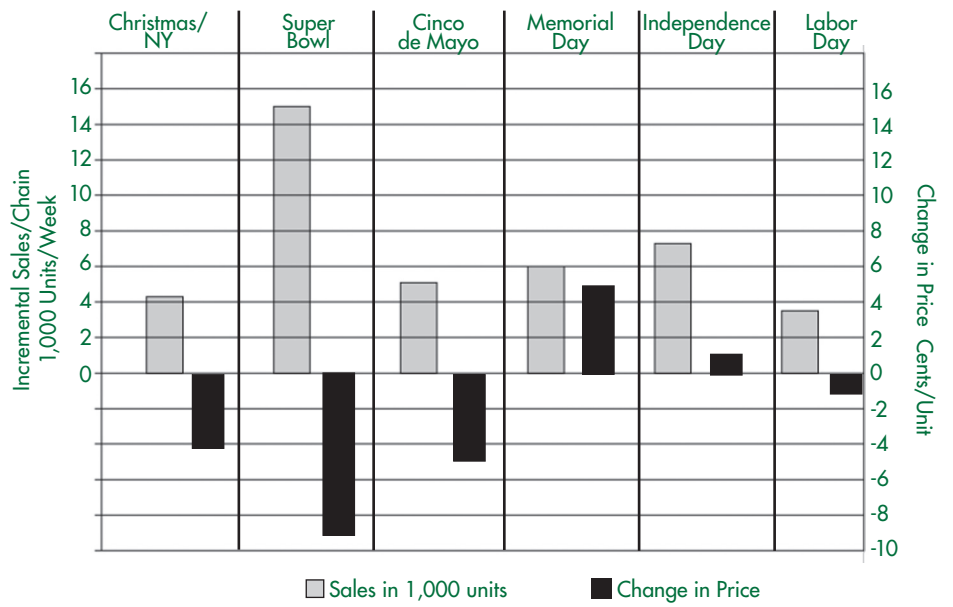
Characteristics of Demand for Hass Avocados

An estimated retail-sales response model provides basic information on the retail demand for Hass avocados. The average retail account in the database had average weekly sales of just over 34,669 units of Hass avocados for each size. The estimated own-price elasticity of demand for Hass avocados evaluated at the sample means is –2.2 and is highly significant, suggesting that demand for Hass avocados at the individual-retailer level is quite elastic (responsive to price). We did not find any evidence of consumer stocking of avocados in response to low-price specials, which is consistent with the perishability of fresh avocados.

The estimated models reveal evidence of rising retail prices and sales for avocados, with prices and sales slightly higher in marketing year 2003 and significantly higher in marketing year 2004 than in the base 2002 marketing year. This result is consistent with other research conducted at UC Davis that found annual U.S. demand for avocados increasing significantly over time in response to increased consumer income, industry-funded promotion programs, growth in Hispanic population, and other factors such as the increased popularity of Mexican foods.

Monthly demand for avocados varies seasonally. Demand was high during the summer months, May through September, with June having the highest monthly demand. Although retail prices in the high-demand summer months were not significantly different from other months, the farm-retail price spreads

Figure 1. Effects of Holidays/Events on Retail Sales and Prices for Hass Avocados



were significantly lower in May and June, and the probability of temporary price reductions (i.e., sales) was significantly higher in May, July, August, and September. Retail prices were significantly lower as a function of the amount of avocados imported from Chile and Mexico, meaning that consumers have benefited from imports and trade liberalization for avocados.

We also see evidence of price effects for some events and holidays. Six holidays/events: Christmas/New Year, Super Bowl Sunday, Cinco de Mayo, Memorial Day, Independence Day, and Labor Day, had significantly higher demands in the shopping week(s) preceding and/or during the holiday/event (Figure 1). Among the six holidays/events associated with significantly higher avocado sales, Christmas/New Year, Super Bowl Sunday, and Cinco de Mayo are associated with significantly lower prices (Figure 1), lower retail margins, and higher incidence of temporary price reductions. Super Bowl Sunday had the strongest effect on sales and retail pricing among holidays/events. Although prices were significantly higher in the weeks associated with Memorial Day, retail markups were not significantly higher, and temporary price reductions were more likely to take place, but not significantly. Independence Day and Labor Day had no significant effects on retail pricing.

The estimation results thus offer some evidence that retail prices and retail markups are lower, and the probability of sales is higher during high-demand periods for avocados. First, retailers were more likely to conduct temporary price reductions during almost all the summer months when demand for avocados was high. The retail price for avocados was significantly lower in May, and the retail margin was significantly lower in May and June relative to the January base. Second, the retail price and markup were significantly lower, and the probability of temporary price reductions was significantly higher during holidays and events associated with significantly higher demand for avocados, in particular Super Bowl Sunday and Cinco de Mayo. We normally think that higher demand is associated with higher prices, but these results for avocados are consistent with results obtained by other researchers for different products.

Retailers' pricing practices for fresh produce are a critically important determinant of producers' and handlers' incomes.

Photo Credit: UC Regents

CAC Promotion Programs

The fact that the CAC selected a set of markets for its promotions during particular times of a year enables us to construct treatment and control groups and a before-and-after design for program evaluation. The approach of "difference-in-difference" is employed to estimate the counterfactual retail demand for the selected markets that received the CAC's promotion programs. Unobserved temporary factors and idiosyncratic retailer and market characteristics that might contribute to changes in demand are isolated to achieve a "clean" identification of the effects of the CAC's promotion programs.

The analysis demonstrates that the CAC's radio campaign and outdoor advertisements were successful in raising avocado sales in the 11-12 major markets where the CAC conducted its promotions during the time period of our analysis. The presence of the radio (outdoor) campaign in the treated market was associated on average with 7,058 (8,822) more units sold for each size of Hass avocados at a retail account in one week. Neither the radio nor outdoor campaigns had a significant impact on retail price, or on retail markup on average. The retail price and markup were lower (higher) during the radio (outdoor) campaigns, but the effect was negligible and insignificant. However, retailers were more likely to hold temporary price reductions during the CAC's promotion programs. In particular, retailers tended to conduct significantly more temporary price reductions during the radio promotions. Lower retail price and markup, and more frequent temporary price reductions during the radio promotions suggest that retailers responded more actively to the radio advertising than to the outdoor promotions, and that their response was at least mildly supportive of the CAC's programs. In particular, there is no evidence that retailers raised price to choke off the promotion-induced demand expansion.

Concluding Comments

Our results regarding retailers' pricing for avocados are probably applicable to other produce products with similar characteristics. We would not be surprised, for example, to find for other specialized perishable products with moderate sales that (i) the product is priced lower when demand is high, (ii) changing procurement costs are not a major determinant of retail prices, (iii) retailers increase their margins when weekly shipments are increasing, and (iv) retailers' pricing practices mildly support, or at least do not offset, industry-advertising programs.

Lan Li received her Ph.D. from the Department of Agricultural and Resource Economics at UC Davis, where Hoy Carman and Richard Sexton are professors. They can be reached by e-mail at lan.li@latrobe.edu.au, carman@primal.ucdavis.edu and rich@primal.ucdavis.edu, respectively.

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OECD Support for Agriculture: Has it Historically Harmed Poor Countries?

Alix Peterson Zwane and Margaret McMillan

This article summarizes recent research that assesses the impacts of the agricultural policies of rich countries on poverty in developing countries. A central message of this research is that, because of the diversity both within and among developing countries, the extent to which rich-country support policies translate into lower incomes in poor countries varies on a country-by-country basis. Many least-developed countries, especially in Africa, are net importers of food. As net food importers, they may be hurt by higher commodity prices.

Rich countries are under increasing pressure from around the work to end support to agriculture. Agricultural subsidies and price supports (mainly given to bulk-commodity producers and dairy farmers in the U.S.) allow the industrialized countries that are members of the Organization of Economic Cooperation and Development (OECD) to sell their agricultural products on world markets at prices that are below the cost of production. California farmers have often complained that such support policies make it difficult for them to compete in foreign markets, as many European specialty-crop producers receive government assistance that they do not get. Competitive producers of bulk commodities in countries like Australia have made similar complaints about U.S. cotton and corn producers. Consumer advocates and agricultural economists have often emphasized the perverse effects of these policies on land and food markets here at home. Many observers outside of the agriculture sector, on the other hand, have focused on the concern that these policies are likely to hurt the poorest residents of poor countries. Because many poor people in developing countries are farmers, eliminating support for rich-country farmers will raise world prices and thus the incomes of the poor. This argument for agricultural policy reform has been particularly common in recent years as the current round of trade talks at the World Trade Organization (WTO) has been dubbed the "development round," and the chance for developing countries to experience benefits from increased trade and globalization.

In recent work, we have evaluated these development-related arguments for trade liberalization systematically by measuring the impact of OECD agricultural policies on poverty in developing countries. A central message of this research is that, because of the diversity both within and among developing countries, the extent to which rich-country support policies translate into lower incomes in poor countries varies on a country-by-country basis. Many least-developed countries, especially in Africa, are net importers of food. As net food importers, they may be hurt by higher commodity prices. Some countries may import cereals, such as maize and rice, but export other agricultural products such as sugar or cotton. Higher prices for exports and imports will have net effects that are difficult to predict ex ante. Even within importing countries, the poorest members of society may be net sellers of food.

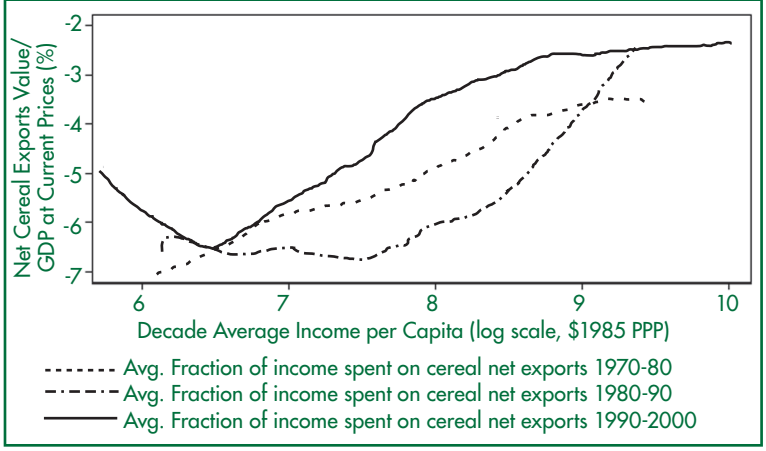
In this article, we review some of our analysis documenting the relationship between income per capita and the value of net cereal, food, and agricultural (food plus non-food) exports for each of the three decades leading up to 2000. We find that—on average—the poorest countries have historically been net importers of cereals and food, the products most heavily supported by the OECD countries, just as they are today. We encourage readers to turn to our complete paper, available at www.nber.org/papers/w11289, for a discussion of additional cross-country regression analysis and a case study of the impact of NAFTA on poor corn farmers in Mexico.

The Agricultural Trade Position of Developing Countries

We investigate the relationship between income per capita (measured in constant 1985 dollars at Purchasing Power Parity exchange rates (which account for variations in relative prices between countries) and collected from the Penn World Tables version 6.1) and the value of net cereal, net food, and net agricultural exports including non-food products as a share of GDP (measured at current prices). This can be thought of as the fraction of current income earned from the sale of these products or spent to purchase these products. Because there is time-series data on agricultural imports and exports, as well as income, it is possible to track the behavior of the cohort of developing countries over time.

We identify the countries that may have been most affected historically by OECD agricultural policy as those that have spent (earned) the greatest fraction of income on imports (exports) of supported products. We

Figure 1. Net Cereal Exports & Income Per Capita, 1970 2000



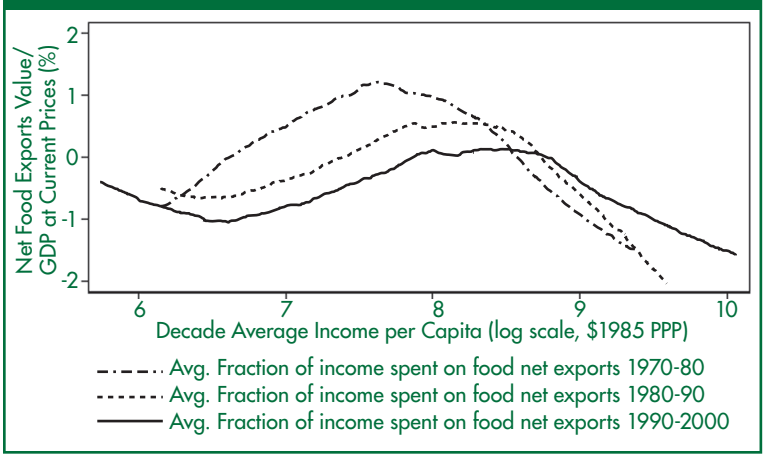
are particularly interested in comparing how cereal importers differ from food or non-food agricultural exporters. While cereals prices are depressed by OECD agricultural support policies, the prices of most other food products (with the important exceptions of dairy and sugar) and non-food products (with the important exception of cotton) are largely unaffected by OECD support.

Figures 1, 2, and 3 present data on income earned from agricultural exports in three different ways. First, we use data from the FAO to calculate the value of annual net cereal exports as a percentage of GDP for a sample of 99 developing countries and take the average value of this number for the period 1970-1979, 1980 -1989, and 1990-2000. We show the cross-sectional income profile for these three time periods in Figure 1 by using a locally-weighted regression of decadal average cereal export share on the decadal average of the log of income per capita (bandwidth = 0.8). We run the same regressions for food export share and present those results in Figure 2. Figure 3 shows the regressions for agricultural export shares (including non-food products such as green coffee and fibers).

Figure 1 shows that, in each decade, the poorest countries spend the largest fraction of their incomes on cereal imports, suggesting that they may experience net benefits as a result of depressed cereal prices. In fact, so few developing countries are net cereal exporters in any decade that the predicted net cereal export share is negative even at the highest income levels observed in the data.

Since 1970 the poorest countries have also experienced the smallest reduction in net expenditures on cereal exports as a share of GDP. To trace the average cereal export share of a given country experiencing economic growth, points should not be connected within years, but across the regression lines, linking up the experience and behavior of a like country in the following decade. Thus, the fact that the regression lines are very close to each other at the lowest levels of income suggests that net export increases experienced at higher income levels largely bypassed the poorest countries in the post-colonial era.

Figure 2. Net Food Exports & Income Per Capita, 1970 2000



These data suggest that depressed prices for food products may hurt middle-income countries but help the poorest and richest developing countries. As shown in Figure 2, and unlike in the case of cereals alone, among non-OECD countries only middle-income countries earn income from food exports. The cross-sectional relationship between net earnings from all food exports as a share of GDP is non-monotonic. This production category includes non-cereal products that receive high levels of support in the OECD, including sugar, beef, and dairy products, as well as unsubsidized products such as cocoa and most fruits and vegetables.

Poor countries are most likely to be net exporters of agricultural products in total, as shown in Figure 3. We run the same regressions to create this figure, but consider all agricultural products, including fibers, industrial seeds, green coffee, and tobacco. In this case we find a downward-sloping relationship between net export earnings and income. Relatively well-off developing countries import agricultural products as a whole. This suggests that depressed prices for non-food agricultural products like cotton are particularly damaging to the poorest countries.

Summary and Conclusion

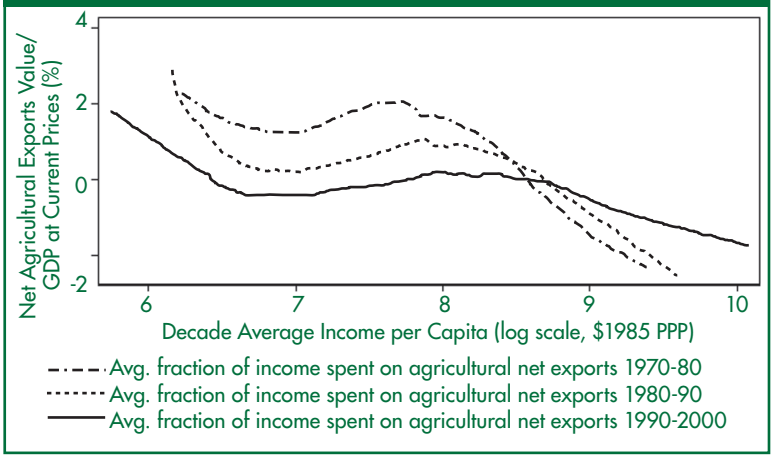
Figures 1, 2, and 3 together provide evidence that many poor countries import cereals but export agricultural products as a whole, and have been in this position throughout the post-colonial era. Many poor countries, and even many middle-income countries, that export food products also import cereals, particularly in the 1990s. Depressed commodity prices as a result of domestic support

for agriculture in the OECD could lower the value of both imported products and exported products for these countries. While it is true that a majority of poor countries are net exporters of agricultural products today, among the non-food products cotton stands out as the only non-food commodity whose price is likely to be significantly depressed by OECD agricultural support.

Of course the experience of developing countries is diverse and, because they are regressions, Figures 1 through 3 obscure differences in countries' experiences at any income level. However, these results suggest that it is unlikely that broad agricultural liberalization, which is likely to result in higher world prices for cereals as well as dairy, sugar, and cotton, will benefit the majority of the poorest countries. On the other hand, country-level average values of net cereals or food exports tell us little about what happens to the poor within a country. Even in countries that are net importers of food, the poor may be net exporters of food. Thus, a poor country might be hurt by higher food prices while the poor within that country benefit from higher food prices.

In our research we find no support in cross-country regression analysis for the claim that OECD policies have worsened poverty in developing countries on average or for the particular claim that liberalizing U.S.-Mexico agricultural trade has harmed poor corn farmers in Mexico. Our results stand in stark contrast with the large body of literature that has been devoted to examining the potential impact of agricultural trade liberalization on developing countries using computable general equilibrium (CGE) models. While the magnitudes of CGE estimates vary, agricultural trade liberalization is typically predicted to increase world commodity prices to the overall benefit of developing countries. Probably the most important reason for the differences in results is that other studies have not focused explicitly on poverty, but rather on developing countries as a whole. Additionally, many studies combine liberalization by developing countries with liberalization by developed countries when estimating welfare impacts. We focus solely on the impacts of rich-country polices on poor countries and the poor residents of these countries. Nonetheless, our work suggests that hopes for important income gains in poor countries, as a result of broad-based agricultural trade liberalization by rich countries, may be misplaced. Rather, most of the benefits of this trade liberalization will be captured by growers and consumers in a handful of well-off, agriculturally competitive economies.

Fig 3. Net Agricultural Exports & Income Per Capita, 1970 2000



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For additional information, the authors recommend the following sources:

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