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The Implications of an E10 Ethanol-Blend Policy for California

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We evaluate the effects of an E10 ethanol-blend policy on ethanol consumption and greenhouse gas reduction in California. Under an E10 policy in California, the ethanol consumption in 2020 under the base case scenario will be 1.68 billion gallons. The average greenhouse gas emission reduction in 2020 using an E10 policy for the present combination of feedstock will be 1.37% compared to the current E5.7 blend.

National attention has emerged in support of biofuels development and use. The motivating factors include high oil prices, security concerns from relying on foreign energy sources, support for economic growth in the U.S. agricultural community, and environmental goals related to criteria pollutants and climate change emissions. Given the existing production infrastructure and experience with fuel blending, the biofuel of choice is currently ethanol. Currently, gasoline fuel in California includes approximately 5.7% ethanol (E5.7).

E10 is a fuel mixture of 10% ethanol and 90% gasoline that can be used in the internal combustion engines of most modern automobiles and light-duty vehicles. E10 blends are mandated in some areas for emissions and other reasons.

The effects of an E10 ethanol-blend policy in California are uncertain. In California, ethanol fuel or corn feedstock is largely imported from midwest states creating interstate transport challenges. Ethanol fuel cannot be transported in the fuel pipeline system and needs to be blended with gasoline near the end-market locations. Additionally, certain blend fractions of ethanol in gasoline can increase evaporative emissions and permeation, resulting in larger air quality concerns. Moreover, especially in California, E10 from corn is supported largely because it facilitates the transition away from petroleum and toward biofuels. But this issue has not been thought through, and is subject to a variety of uncertain assumptions.

How much ethanol would be consumed in CA each year for the next ten years if there were a mandatory E10 policy? To obtain estimates of future ethanol demand we estimate gasoline fuel demand under several different scenarios and use the projected demand to estimate the required ethanol quantity under an E10 policy. We estimate ethanol consumption based on projections of fuel demand as a base case, and then analyze different scenarios.

In order to estimate the required ethanol quantities under an E10 mandate, we first estimate future gasoline fuel demand. The estimation of demand models for gasoline has produced varying results over the past few decades and continues to be a subject of great interest. Estimates drawn from analysis that includes recent data and California-specific data are scarce, however.

A key parameter in the estimation of gasoline demand is the price elasticity of demand, which measures the percent change in gasoline demand for a percent change in gasoline price. It is a measure of how responsive consumers are to changes in the price of gasoline. The higher the elasticity in magnitude, the more consumers will decrease gasoline consumption in response to an increase in gasoline price. According to six previous studies estimating the elasticity of demand for gasoline,

Also in this issue

Figure 1. California Gasoline Price, 2008 Dollars per Gallon

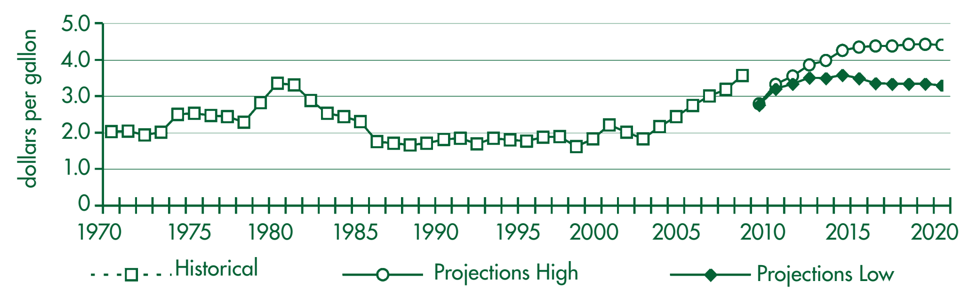


Figure 2. California Population in Millions

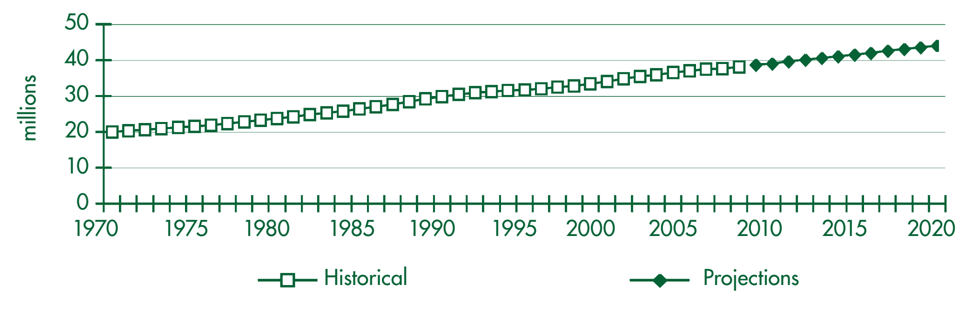
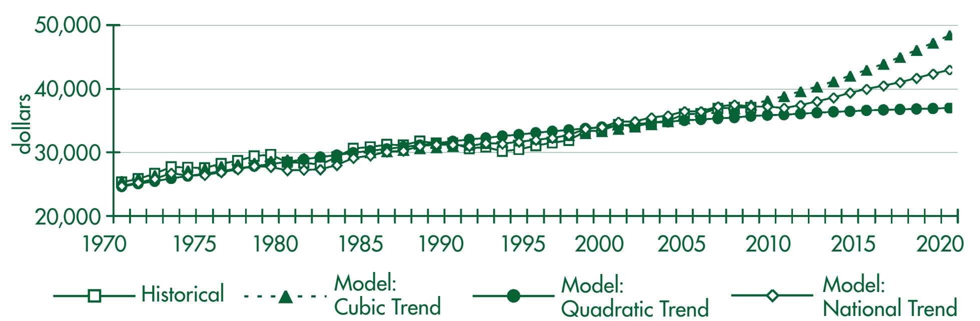


Figure 3. California Per Capita Disposable Income, in 2008 Dollars



using data spread over the years 1929 to 2000, the mean short-run elasticity ranged from –0.25 to –0.28. Short-run elasticities measure the responsiveness over a time span of several months. One recent study, Hughes et al. (2008), shows that demand has become more inelastic over the recent years. In particular, they find that short-run elasticities have decreased by up to an order of magnitude from a range of –0.21 to –0.34 for the years 1975 to 1980, to a range of –0.034 to –0.077 for the recent years 2001 to 2006.

To determine how much ethanol would need to be supplied in California each year from 2010 to 2020, if there were a mandatory national E10 policy that required 10% of the fuel blend to be ethanol, we start with a model of fuel demand for California:

$$\ln D_t = b_0 + b_1 \ln P_t + b_2 \ln Y_t + e_t$$

where ln*X* is the natural log of the variable *X*, D_t is per capita gasoline demand in gallons per day for year *t*, P_t is the real price of gasoline in 2008 constant dollars in year *t*, Y_t is real per capita disposable income in 2008 constant dollars in year *t*, and e_t is a mean zero error term. The coefficient b_1 is the price elasticity of demand over the intermediate run, which spans a time frame of a few years. We would like to use this model for gasoline demand to project fuel demand from 2010 to 2020. Under an E10 policy, 10% of this fuel demand would have to be ethanol.

We run our regression model estimating the demand for gasoline in California using data from 1970 to 2007. To address the identification problem inherent in estimating demand, industrial production in India is used as an instrument for California's gasoline price. Industrial production in India is an ideal instrument for California's gasoline price because it is correlated with California's gasoline price but does not have a direct effect on the demand for gasoline in California. The results, with the standard errors in parentheses, are:

$$\begin{aligned}\ln D_t = &-5.005 - 0.221 * \ln P_t + 0.512 * \ln Y_t\\ &\ (1.522)\quad (0.097)\qquad\quad (0.166)\end{aligned}$$

In particular, we find the intermediate-run price elasticity of demand for gasoline in California to be –0.221. Unlike the previous estimates of the elasticity of demand, our estimate is specific to California and the data used in its estimation include data from recent years. In alternate specifications, we also use a range for the elasticity, from –0.101 to –0.28, which encompasses the range of mean elasticities found in the literature.

To project California's future fuel demand, we used projections of California gasoline price, California per capita disposable income, and California population in our model for California gasoline demand. Retail gasoline price projections are from the "Transportation Fuel Price and Demand Forecasts: Inputs and Methods for the 2009 Integrated Energy Policy Report," prepared by the California Energy Commission (CEC). The data are in 2008 dollars and include a high-price scenario and a low-price scenario. The projections incorporate the E10 policy. CEC staff expects the policy would raise the price of gasoline. The projected price, along with historical price data, are plotted in Figure 1.

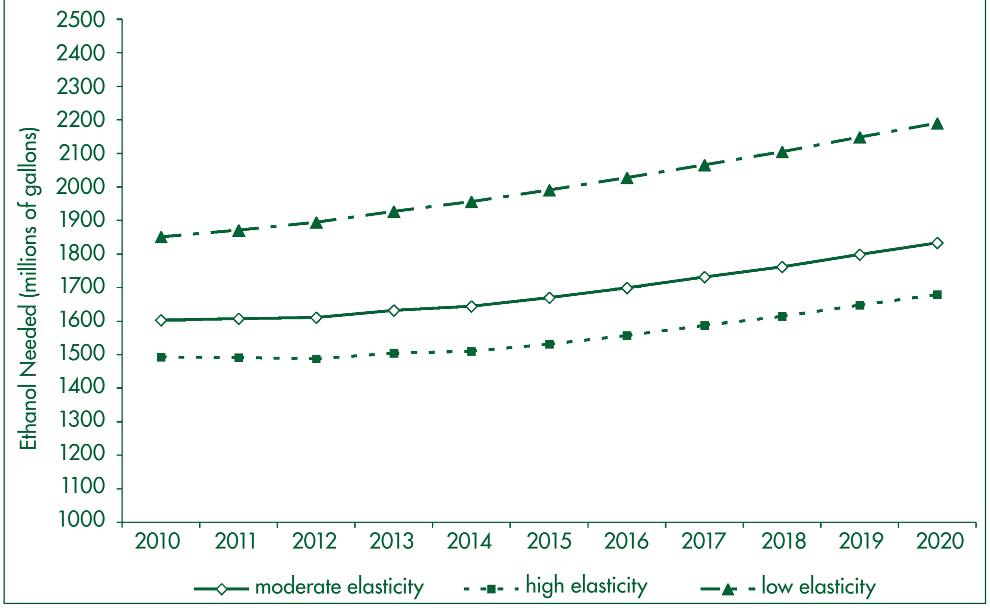
For California population, we use the projections from the California

Department of Finance's report on "Race/Ethnic population with Age and Sex Detail, 2000-2050." Figure 2 plots the historical and projected population.

For California per capita disposable income, we construct three models, from which the predicted values are plotted with the historical data in Figure 3. The first model, Quadratic Trend, is based on a regression of historical California per capita disposable income on time and time squared. The second model, Cubic Trend, is based on a regression of historical California per capita disposable income on time, time squared, and time cubed. The third model, National Trend, is based on a regression of historical California per capita disposable income on historical U.S. per capita disposable income. National historical per capita disposable income data used in the regression are collected from Bureau of Economic Analysis. Projections of national per capita disposable income data used to project the California per capita disposable income are from the Energy Information Administration.

Figure 4 presents estimates of the ethanol needed in California under an E10 policy, using the high-price scenario and the income projected using the national trend. The main assumption used is that the fuel market will be dominated by gasoline over 2010–2020, and ethanol will be used as a 10% additive to gas. The graph presents projections under three elasticities (low= –0.101, moderate= –0.221 and high= –0.28). Using the low-price scenario instead of the high-price scenario, and the quadratic or cubic trends for income instead of the income projected using the national trend, produces similar results. For the base-case scenario of high fuel prices, income as projected using the national trend and moderate elasticity, the ethanol consumption in 2020 under an E10 policy will be 1.68 billion gallons. When considering all 18 price-income-elasticity scenarios, the ethanol consumption in 2020 under an E10 policy will range from 1.56 billion to 2.40 billion gallons.

Figure 4. Projections Using the High Price Scenario and Income Projected from the National Trend



Ethanol has a high octane number and can increase the octane of gasoline (or cetane number for biodiesel). This will lead to better fuel efficiency for vehicles with ethanol-blended fuel. On the other hand, the average energy content of gasoline (114,000 Btu/gallon) is higher than that for ethanol (76,000 Btu/gallon). As a result, ethanol-blended fuel will have lower energy content. Different studies have found a wide range of fuel economy for ethanol-blended fuels. Some report slightly worse fuel economy than pure gas-fueled vehicles, while others report substantially better. Other factors such as motor load, temperature, and traffic congestion may also affect the relative fuel economy of cars with and without ethanol-blended fuel.

If as an average, we considered 5% more fuel efficiency for E10 fuel then, if the VMT and fuel efficiency stays the same with and without an E10 policy so that the total fuel demand is 5% lower, the ethanol consumption in 2020 under an E10 policy would be from 1.55 billion to 2.39 billion gallons. Nevertheless, the rebound effect, in which consumers might respond to the increased fuel efficiency for E10 fuel by driving more or buying less fuel-efficient cars, can offset some of this effect.

The amount of greenhouse gas emissions from ethanol-blended fuel depends on the type of feedstock used to produce the ethanol. Ethanol produced by cellulosic feedstock has low greenhouse gas emissions, while corn ethanol has relatively high greenhouse gas emissions.

The International Energy Agency has compiled data from different studies on the well-to-wheels greenhouse gas emissions from different types of ethanol compared to those from gasoline fuel (per km traveled). For corn ethanol, the greenhouse gas emissions range from a 30% increase to a 47% decrease compared to gasoline fuel, with an average of approximately 25% decrease. For cellulosic ethanol, the greenhouse gas emissions vary from a 51% to 117% decrease, with an average decrease of approximately 70%. According to Macedo (2001), the greenhouse gas reductions from sugarcane ethanol is about 90%. In addition to feedstock, the greenhouse gas emissions also depend on the production process (e.g., dry or wet mill).

Table 1. California's Consumed Ethanol Feedstock Scenarios

	Imports from other countries (mainly sugarcane)	Corn (either domestic or imports from other states)	Cellulosic	Sugarcane
Present	10%	89%	1%	–
High-emission scenario	–	95%	5%	–
Low-emission scenario	20%	40%	25%	15%

Table 2a. GHG Percent Reduction Using E10 Compared with 0% Ethanol

Present	lower bound	–2.07
	upper bound	5.50
	average	3.20
High-emission secenario	lower bound	–2.19
	upper bound	5.40
	average	2.95
Low-emission scenario	lower bound	2.00
	upper bound	9.01
	average	5.90

Table 2b. GHG Percent Reduction Using E10 Compared with Current Blend

Present	lower bound	–0.89
	upper bound	2.37
	average	1.37
High-emission secenario	lower bound	–0.94
	upper bound	2.32
	average	1.27
Low-emission scenario	lower bound	0.86
	upper bound	3.87
	average	2.54

In order to project the effects of an E10 policy on greenhouse gas emissions, one must therefore predict the sources of ethanol feedstock for California. This is a hard job because we do not know the future combination of feedstock that may be used to produce ethanol. In 2004, California's total ethanol production was about 33 million gallons, which was 3.7% of domestic ethanol production. The current ethanol refineries in California are two plants in the Los Angeles area that use waste products and residuals from food and beverage as feedstocks, and new corn-to-ethanol plants mainly in Central Valley with about 65 million gallons capacity.

We used two different scenarios for the future: (1) a high greenhouse gas emissions scenario based on more corn-based ethanol, and (2) a low greenhouse gas emissions scenario based on more imports from sugarcane-based ethanol producers or more production of cellulosic or sugarcane-based ethanol. The scenarios are presented in Table 1. Currently, imports are assumed to be from other countries, not other states. Most of the domestic ethanol from outside is from central or eastern states, which will lead to high transportation costs. If greenhouse gas emissions and future costs are of concern, cellulosic- or sugarcane-based facilities should be constructed, since (1) California has the potential for sugarcane production, (2) sugarcane has lower costs and lower emissions than corn, (3) cellulosic ethanol will be cheaper in the future and has lower emissions than corn, with a range of –0.94% to 3.87%, and (4) transportation cost both for transporting corn or ethanol will be higher than using available cellulosic or sugarcane feedstock.

We apply the greenhouse emission reduction ranges and averages for each feedstock to the feedstock combination scenarios in Table 1 to project upper bounds, lower bounds, and averages for the greenhouse gas emissions reductions in 2020 of an E10 policy compared to gasoline fuel. Table 2a shows the greenhouse gas reductions comparing the E10 policy to a 0% ethanol blend; Table 2b compares the E10 policy to the current ethanol blend in California of E5.7. As shown in the table, the average greenhouse gas emission reduction in 2020 using an E10 policy for the present combination of feedstock will be 3.20% compared to 0% ethanol, and 1.37% compared to the current E5.7 blend. The average greenhouse gas emission reduction in 2020 using an E10 policy for the high-emissions scenario will be 2.95% compared to 0% ethanol, and 1.37% compared to the current E5.7 blend. The average greenhouse gas emission reduction in 2020 using an E10 policy for the low-emission scenario will be 5.90% compared to 0% ethanol, and 2.54% compared to the current E5.7 blend.

If implemented, an E10 policy in California would have impacts on ethanol consumption and greenhouse gas emissions, among other effects. Under an E10 policy in California, the ethanol consumption in 2020 will range from 1.56 billion to 2.40 billion gallons, with a base case value of 1.68 billion gallons. The average greenhouse gas emission reduction in 2020 using an E10 policy for the present combination of feedstock will be 1.37% compared to the current E5.7 blend, with a range of –0.94% to 3.87%.

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Does Local Production Improve Environmental and Health Outcomes?

by Steven Sexton

Some critics of industrial agriculture propose the "relocalization" of food production to reduce environmental damage and improve health outcomes. This article considers the welfare effects of locavorism along these dimensions.

Modern agriculture is increasingly under attack by critics who blame the industry's specialization and concentration for a number of societal problems, from global warming to rising health care costs. The critics contend that today's industrial agriculture is too dependent on fossil fuel, and too eager to ply consumers with cheap but nutritionally bankrupt calories. Among the critics, locavores, like best-selling author of *The Omnivore's Dilemma* Michael Pollan, and famed chef Alice Waters, advocate a community-based food production system in which consumers buy goods that have travelled less than 150 miles from farm to fork.

The rise of modern farming would seem to be one of the great successes of the last century. Propelled by the Green Revolution, agricultural productivity in the United States grew at an average 1.9% per year from 1948 to 1998, exceeding the rate of growth in the U.S. manufacturing sector. Similar productivity gains were achieved elsewhere around the world. A doubling of food production in the second half of the 20th century saved the world from mass starvation as its population doubled to six billion. Because of modern agriculture, farmers were able to produce more food per person for more people—without expanding farmland or farm labor demand. In fact, 50 million acres of land were released from farming in the United States over the last half-century, and the percentage of the national workforce employed in agriculture fell from 16% to less than 2%. Norman Borlaug, considered the father of the Green Revolution, credits science with saving from conversion to farming an area of land equal to the U.S. east of the Mississippi River.

Critics of our current food system don't deny these achievements. But they blame the transition to industrial farming for simultaneous increases in the amount of energy embedded in food products and heightened rates of obesity among the American public. The case against industrial agriculture has been articulated in major box-office draws like "Food, Inc.," and "Supersize Me," featured in cover stories for *Time* and the *New York Times Magazine*, and detailed in *New York Times* bestsellers by Pollan.

Amid growing concern about climate change and health care costs, it has become almost conventional wisdom that the federal government's farm program has created a food production and marketing system that poorly serves societal interests and that new policy is needed to coordinate a return to our agricultural roots. Economic theory and empirical evidence suggest, however, that this new conventional wisdom may be quite wrong. This article considers whether a food system based on local production would improve outcomes in the key areas its proponents assert the current system lets us down: human health and environmental preservation.

Climate Change and the Environment

As recently as the 1930s and 1940s, when horses and mules still provided the bulk of power on American farms, food output contained twice the energy consumed in production. But today, ten times more energy is consumed in production than is yielded in food output. Energy has become an important input at every step of the supply chain, from the production of chemical inputs upstream from the farm to the processing of raw material into finished food products downstream. And on the farm, 4.3 million fossil fuel-powered tractors have replaced the 21.6 million work animals that occupied farms in 1900.

As farms became increasingly specialized, reducing the average number of commodities produced per farm from about 5 in 1900 to about 1.5 today, demands for soil enhancements and damage-control agents grew. Specialization and trade also increased demand for energy to transport crops and food products to buyers. It is estimated that today's fresh produce travels an average 1,500 miles from the farm to the consumer. As a consequence of the energy demands throughout the supply chain, agriculture consumes 14% of the national energy budget. Transportation of food products alone consumes 5%.

Locavores argue that to accomplish environmental objectives, the food production system must be transformed to one characterized by small farms growing multiple crops and marketing them directly to consumers or local retailers. The "relocalization" of the food system demands a farming landscape that resembles our agricultural past. Farming in the 1930s, in fact, looks a lot like what the critics of industrial agriculture hope to achieve today: 5.7 million farms averaging 147 acres in size and growing an average 5.1 different crops.

Implicit in the locavore assertion that local farming is environmentally friendly relative to industrial agriculture is an assumption that altering the scale and location of agricultural production does not alter its efficiency. Holding all else constant, a reduction in food transportation miles and an increase in biological control of pests and soil fertility, necessarily reduces the carbon intensity of food production. However, all else is not likely to be constant under such a transformation.

Locavores presume that we can return to a historical form of agriculture without also returning to historical farm yields. The average farmer produced 13 bushels of wheat per acre in 1930 and 20 bushels of corn. In contrast, today's farms, which number only 2.2 million and occupy an average 414 acres, are able to produce an average 44 bushels of wheat and 164.2 bushels of corn per acre.

While it is surely true that a small, diverse farm today can improve upon the yields of the early to mid-20th century by employing modern seed varieties and other scale-neutral innovations, it is certainly also true that high yields today reflect modern agriculture's exploitation of two basic principles of economic efficiency that the locavores either ignore or discount: comparative advantage and economies of scale. It is the inability of a local food system to exploit these forces that could render it a net contributor to global warming and environmental damage rather than a net reducer.

Specialization and Trade: Economists have long recognized the welfare gains from specialization and trade. The case for specialization is perhaps nowhere stronger than in agriculture, where the costs of production depend on natural resource endowments such as temperature, rainfall, and sunlight, as well as soil quality, pestilence, and land costs. Because ideal growing conditions and crop sensitivity to deviations from optimal conditions vary by crop, different regions enjoy comparative advantage in different crops. As a consequence, California, with its relatively mild winters, warm summers, and fertile soil is the leading producer of high-value crops, producing all U.S.-grown almonds and 80% of U.S. grapes and strawberries. Iowa, in contrast, with a less ideal agronomic resource endowment, specializes in corn and soybeans, providing nearly 20% of all U.S. production of these less-valuable crops.

Table 1. Psuedo-Locavore Effects on Input Costs

Change in Millions	Corn	Soybeans	Oats	Change in Millions	Milk
Acres	22.06	13.82	0.95	Head of Cattle	0.64
	26.91%	18.26%	37.36%		7.58%
Fertilizer Costs	$39.01	$30.69	$86.10	Purchased Feed Costs	$-420.26
	35.07%	54.90%	61.88%		0.03%
Chemical Costs	$45.66	$61.64	$-0.46	Homegrown Feed Costs	$7.32
	23.07%	20.04%	-8.71%		0.11%
				Grazed Feed Costs	$33.04
					22.60%
Fuel Costs	$88.60	$32.60	$14.95	Fuel Costs	$25.16
	22.80%	33.92%	27.24%		1.72%
Total Input Costs	$71.62	$35.47	$12.73	Total Input Costs	$-257.74
	29.45%	29.54%	44.77%		-0.93%

The dramatic change in land-use and input-demand induced by a "relocalization" of the food supply is demonstrated using USDA region-level production cost and return data and state-level data on production, land allocations, and yield. To derive a first-order approximation of locavore effects on production costs and input demands, assume that a local food system must maintain existing levels of per capita production for each crop. Further, assume that each state must produce all the food for its residents. These assumptions reallocate production so that each state produces an average "diet" for each if its residents. Because of data limitations, production is reallocated in this analysis for each crop only over those states for which a complete set of data exists. For instance, yield data for a given crop do not exist for states that are not currently producing that crop, so it is impossible to determine input demands.

Using the regional mean production costs and state-level data on yield, the input-demand under this "proportional" or "pseudo-locavore" production system is determined. This analysis is carried out for four major crops—corn, soybeans, oats, and milk. Results are reported in Table 1. Proportional corn production among current corn producers results in a 22 million acre (26%) increase in area planted to corn, a 35% increase in fertilizer costs, a 23% increase in fuel costs, and a 29% increase in total input costs. Similar results are reported for the other two field crops considered in this analysis. Notably, however, results for milk suggest that production costs decrease under the "pseudo-locavore" scenario, and purchased feed is substituted for grazing and feed produced in the dairy farm. The changes in feed consumption suggest carbon savings relative to the status quo, but the increased number of cows would induce more carbon emissions. Because of the way data for milk are reported, the change in head of cattle accounts for efficiency differences across states, where as input costs do not.

If a national price for inputs is assumed, these input cost changes can be interpreted as changes in input demand,

Table 2. Change in Cropland by State

State	Thousand Acres
Top 5 Growth States	
California	40,000
Texas	34,600
Florida	26,000
Iowa	22,100
North Dakota	19,900
Bottom 5 Growth States	
New Hampshire	0.54
Vermont	0.65
Connecticut	1.42
Rhode Island	6.99
Oregon	4.68

so that, for instance, fertilizer use in corn grows 35%. Therefore, this analysis suggests that, in general, a transition to a pseudo-locavore production system leads to considerable growth in the use of carbon-intensive inputs, which would lead to increasing carbon emissions and pollution of natural ecosystems.

Availability of cost and return data limits analysis of input cost effects for a broader set of crops. It is possible, though, to estimate the land-use impacts of pseudo-locavore production using state-level production and yield data. Assuming yields are maintained as additional land is brought into production, the increase in demand for land for each crop associated with the pseudo-locavore rule is determined by multiplying the percentage change in state-level production by the state-level area planted. With 500 state-crop observations, covering 40 major field crops and vegetables, it is estimated that localization would require a 60 million-acre increase in land devoted to producing these crops in producing regions—a 23% increase. Table 2 reports the states that gain the most farmland under local production and those that lose the most, in absolute terms. Extrapolating this change across the 2.26 billion acres of farmland in the United States, the agricultural land base would grow by 214.8 million acres—an area twice the size of California.

Increased demand for energy-intensive inputs and the expansion of farmland cause carbon emissions that reduce, and may overwhelm, the carbon emissions reductions associated with less transportation and monocropping in “relocalized” food systems. Extrapolating the percentage change in fertilizer and chemical demand from reapportioning corn production among corn producers to all U.S. corn production, for instance, suggests pseudo-locavorism would cause a 2.7 million ton increase in fertilizer applications and a 50 million pound increase in chemical use per year. Conversion of natural land to agricultural uses jeopardizes biodiversity and causes an increase in atmospheric carbon. There are immediate emissions from land-use change as biomass is cleared to make room for crops. And, because natural land sequesters more carbon than cropland, there are emissions associated with foregone annual and ongoing sequestration.

Many of the assumptions made in this simple model will tend to produce a conservative estimate of the carbon costs of locavorism. For instance, this analysis is constrained to consider the reallocation of production to states that are already producing a given crop. Locavores would also reallocate production to states that are not already producers in order to meet the 150-mile constraint on food travel. States that are not among current producers should, on average, be relatively costly producers of a given crop because they would otherwise be growing the crop today. Also, in assuming the persistence of existing yields as land-use expands, this analysis ignores any decline in yields that may result from expansion to marginal lands. Further evidence of the conservatism of this approach is the fact that it shows a net reduction in input costs from localized milk production. Were localized production actually more efficient, we would not be seeing increasing average herd sizes and consolidated production.

Because of data limitations, per capita production in producing regions is reallocated among states under the “pseudo-locavore” scenario. This will tend to bias upward extrapolations out of sample, producing larger effects.

Economies of Scale: A local food production system would upend long-term trends of growing farm size and increasing concentration in food processing and marketing. Ending the food market dominance of big agribusiness—large monocrop farms and integrated food processors—is a secondary motive of locavorism, which generally views big business as an insincere steward of the environment and a principal cause of the obesity problem in the United States.

Local food production would largely eliminate scale economies by dividing a national market for food into local “foodsheds” that can only support smaller farms and food-processing operations. To the extent scale economies exist in farming, food processing, and marketing, they permit larger firms to more efficiently convert inputs to outputs. By forsaking these efficiencies, locavorism causes an increase in the quantity of inputs demanded, which increases carbon intensity, and an increase in the price of commodities and food products.

Large monocropped farms are more dependent than small polycrop farms on synthetic fertilizers and tilling operations to restore soil nutrients. They also face heightened pest pressure because they provide a consistent environment for breeding of crop-specific pests. Higher pest pressure increases demand for chemical damage control agents. Disposal of farm residues, like animal waste, also becomes a significant environmental challenge on industrial farms. The direct environmental costs of large-scale agriculture are clearly non-trivial. What is unclear, however, is whether the environmental benefits of small, poly-cropped farms outweigh the loss of efficiencies that are equally well-documented to accompany the increasing scale of production.

Recent work presents convincing evidence that economies do exist and that small farms are relatively inefficient. Catherine Morrison Paul and colleagues analyzed farm-level surveys from 1996–2000 and concluded the presence of "significant" scale economies in modern agriculture. They report that small farms are less efficient in both the scale of their operations and the technical aspects of production. They are "high cost" farms that have unexploited scale economies and consequently cannot compete with large farms.

Human Health

Locavores allege that modern agriculture is responsible, in part, for growing rates of obesity and obesity-related illness among Americans. They argue that flawed public policy has fueled the industrialization of agriculture and produced a glut of cheap but nutrient-deficient calories by subsidizing the major commodities like corn and wheat. Locavores are also critics of processed foods and fast food, coining the phrase "slow foods" to encapsulate their ideal of home production of fresh, raw, and unprocessed commodities. Better policy, they argue, would yield better health outcomes.

This argument, however, is also based on a series of assumptions that seem to belie accepted fact. For instance, agricultural economists have rejected the notion that farm policy is to blame for the obesity epidemic in America. While policy has made grains relatively cheap, it has also made sugar more expensive. Prices for many fruits and vegetables, such as apples, strawberries, tomatoes, and broccoli, have declined over the past 25 or more years, which should increase access to nutrient-dense foods. Where prices for fruits and vegetables have trended upwards, the increases can be attributed to quality improvements, extended availability, and other value-added attributes in processing, such as enhanced product packaging. No identifiable pattern has been found in the price of unhealthy foods relative to healthy foods. Economists have also largely attributed the obesity epidemic to technological innovation that makes labor less strenuous and food products cheaper, meaning people are eating more but burning fewer calories.

Would a local food system improve American diets? In two key respects, the likely answer is no. First, as this analysis has shown, a local food system would greatly increase the costs of food production by imposing constraints on the efficient allocation of resources. The monetary costs of increased input demands from forsaken gains from trade and scale economies will directly bear on consumer welfare by increasing the costs of food. Research shows that as incomes rise, fresh produce as a share of diets increases. Therefore, given that locavorism would effectively make consumers poorer by increasing the cost of food, it is hard to see how local production improves diets or health outcomes.

While it may be beneficial from a health policy perspective to increase the relative cost of grains to reduce the surfeit of cheap calories, it is not clear that locavorism would accomplish this unless cost increases were biased toward grains. Instead the inefficiencies of reallocating food production are likely to be greater for high-value crops like fruits and vegetables so that, if anything, local food production will disproportionately raise the prices of the very foods that should become cheaper from a health policy perspective.

Second, taken literally, locavorism would block access to fresh produce for millions of Americans who live in climates that cannot, for many months per year, grow fruits and vegetables outside climate-controlled greenhouses. Greenhouse production is clearly energy-intensive and would impede environmental objectives. Blocking access to fresh produce would impede health objectives.

Conclusion

Some critics of modern agriculture have articulated an alternative that they assert would improve environmental and health outcomes. It is unlikely the benefits of locavorism are as substantial as has been asserted, and it is possible they are dwarfed by the costs of less efficient production and reduced access to nutritious foods. With the global population expected to grow to more than nine billion by 2050, today we face a challenge to feed the world, much as we did 60 years ago. The sources of tremendous productivity growth in the past, however, are largely exhausted, at least in the developed world, and the rate of productivity growth has begun to decline. If mass starvation is to be avoided in the current century, then we must either forsake natural land, including tropical forests, or renew our commitment to crop science. The debate about the future of agriculture must weigh the uncertain potential for environmental improvements under local production with the more certain risk to vulnerable populations, if food production doesn't increase, or to precious habitat if productivity doesn't increase.

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For further information, the author recommends:

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The 2008 Cotton Price Spike and Extraordinary Hedging Costs

Colin A. Carter and Joseph P. Janzen

Dramatic futures price movements in 2008 caused the demise of a number of U.S. cotton merchants. We outline the events that led these firms to exit and explain how the 2008 price spike resulted in unusual costs of using futures markets for hedging.

Because of the financial crisis, the U.S. Congress has moved to further regulate trade in derivatives, including those used to manage price risk in agriculture. These new regulations would subject most financial derivatives to more stringent capital requirements and margin calls. An October 25, 2009 *New York Times* editorial criticized industry efforts to lobby for regulatory exceptions for commercial hedgers who now trade over-the-counter derivatives. It stated that: "There is no compelling evidence that exchange trading will drive up costs (of hedging)." But the aftermath of the recent boom and bust in cotton prices suggests there may be unusual costs associated hedging on futures exchanges when prices move as dramatically as they did in 2008. This article examines how the 2008 price spike affected cotton merchants who were hedged. Some of these merchants paid the ultimate price and closed their doors.

The Cotton Market

The United States, China, and India produce two-thirds of the world's cotton, with China and India the largest source of mill demand. There has been strong yield growth in all major production regions due to the adoption of improved agronomic practices and *Bt* varieties. Until recently, global cotton use had grown dramatically, increasing by 45% from 1998 to 2007. However, the 2008/09 crop year saw the largest year-over-year decline in global cotton use in over forty years; cotton use fell nearly 10%.

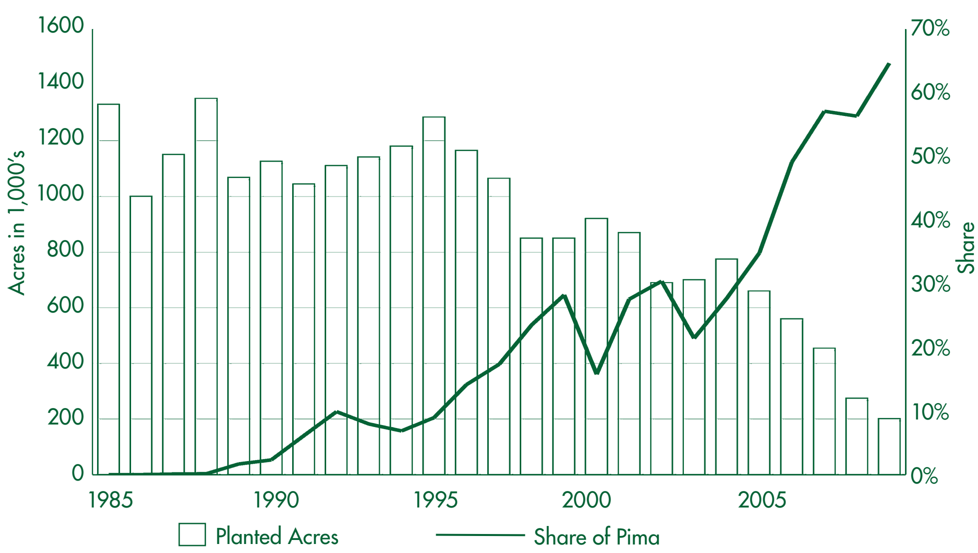
Cotton processing in the United States has been in decline since 1997, as U.S. mills have closed in the face of foreign competition. As a consequence, the U.S. cotton industry now relies heavily on exports and is the largest cotton exporter in the world. Cotton is grown throughout the southern United States and California. Upland cotton, which has relatively short staple length, is produced in all regions. California produces approximately 6% of all U.S. cotton. Due to competition from tree crops and the declining availability of irrigation water, California cotton acreage has declined since the mid-1980s, as shown in Figure 1. As California produced less cotton, it shifted acres to higher quality Pima cotton, a market that is segmented from Upland cotton.

The 2008 Price Spike

Cotton futures are traded on the Intercontinental Exchange (ICE) futures market. This contract has traditionally served as the primary price discovery and hedging tool for U.S. Upland cotton, though merchants also use ICE to hedge purchases outside of the United States. ICE cotton delivery points are located throughout the cotton-producing region, with the exception of California.

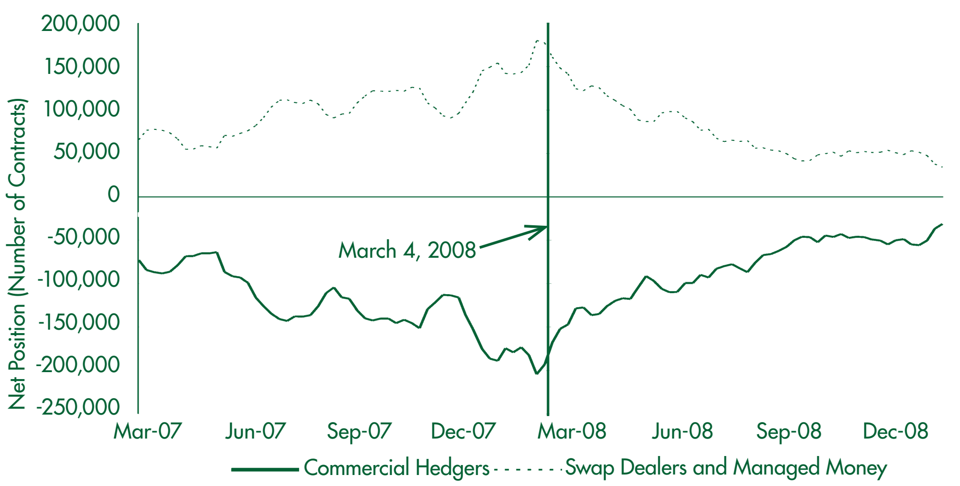
Cotton futures prices began to move higher in late-2007, concurrent with a general commodity price boom. Bullish

Figure 1. California Cotton Acreage and Share of Pima Cotton, 1985–2009



Source: National Agricultural Statistics Service

Figure 2. Net Futures Positions Held by Trader Groups, March 2007–February 2009



Source: Commodity Futures Trading Commission Disaggregated Commitment of Traders Report

sentiment for cotton prices was partly driven by the view that high prices for competing commodities would draw acres towards these crops and away from cotton. It was expected that the number of U.S. acres planted in cotton in 2008/09 would be the lowest of any of the previous 25 years. However, very high levels of end-of-year inventories, both in the United States and elsewhere, should have moderated prices.

In addition, there was new speculative activity in cotton futures. Swap dealers, index funds, and other managed money took a strong interest in all agricultural commodities in late 2007 and early 2008. The Commodity Futures Trading Commission (CFTC) facilitated this flow of new money into agricultural futures by relaxing position limits. It is standard practice for cotton merchants to hedge forward purchases of physical cotton by selling futures. In the presence of greater futures liquidity, merchants increased the size of their short position as they purchased more and more physical cotton. Figure 2 displays the net positions of commercial traders, swap dealers, and managed money, as reported to the CFTC. Commercial hedgers, mostly cotton merchants, were net short 204,443 contracts on February 26, 2008, representing about 21.3 million bales. To place this figure in context, U.S. production was approximately 19.2 million bales in 2007/08 and 12.8 million bales in 2008/09. This means that open futures positions held by commercial hedgers exceeded the size of the U.S. crop. This was a very vulnerable position for cotton merchants.

Cotton futures prices are displayed in Figure 3. At the end of trading on February 29, 2008, May cotton futures closed near contract highs at 81.86¢/ lb. On the next trading day, March 3, cotton prices spiked, hitting limit amounts that stopped trading for the day. Trade in options on these futures contracts continued and observed market volatility increased the risk premium priced into options. On March 4, prices spiked again, with May futures reaching 92.86¢/lb mid-morning. It is believed that the second increase was driven in part by merchants buying futures to unwind the short positions on which they had incurred large losses the previous day.

Futures trading is highly leveraged because traders post ”margin” typically equal to 5–10% of the futures contract value. At the end of each trading day, futures positions are “marked-to-market.” If prices move against the trader, more margin money must be posted. The amount of margin money required in ICE cotton in early March 2008 was based on volatility implied by options prices. Continued trade in options after daily price limits were hit meant that cotton merchants faced unprecedented margin calls.

The cause of the price spike is still unclear, but we do know that cash prices remained far below nearby futures. Average transacted cash prices throughout the cotton belt, normally 4–6¢ under nearby futures, were 25¢ under on March 4. Adding to the uncertainty was the elimination of floor trading for cotton futures; March 3, 2008 was the first day that ICE cotton trading was completely electronic. Anecdotal evidence suggests that commercial firms relied on information relayed by floor traders and this was lost with the move to full electronic trading. After the spike, futures prices fell quickly to approximately 70¢/lb. Subsequently, futures prices declined further, falling below 40¢/lb in early November 2008.

Effects on Merchants

The price spike had significant, negative, and unexpected consequences for cotton merchants. Among others, three large family-owned merchants, all with a presence in California, exited the industry. In November 2008, Weil Brothers Cotton Ltd. announced that it would cease operations in 2010. They were one the oldest cotton merchants in the United States, and were the exclusive marketing arm for California’s San Joaquin Valley Quality Cotton Association. Dunavant Enterprises announced in August of 2009 that it was holding merger talks with Allenberg Cotton, a division of Louis Dreyfus. The conclusion of this merger would combine two of the three largest cotton merchants into one firm. Both Weil Brothers and Dunavant stated that cotton trading had become riskier than in the past and that drove their exit.

The third exiting firm, Paul Reinhart Inc., was the U.S. subsidiary of Swiss firm Paul Reinhart AG. Reinhart filed for bankruptcy protection on October

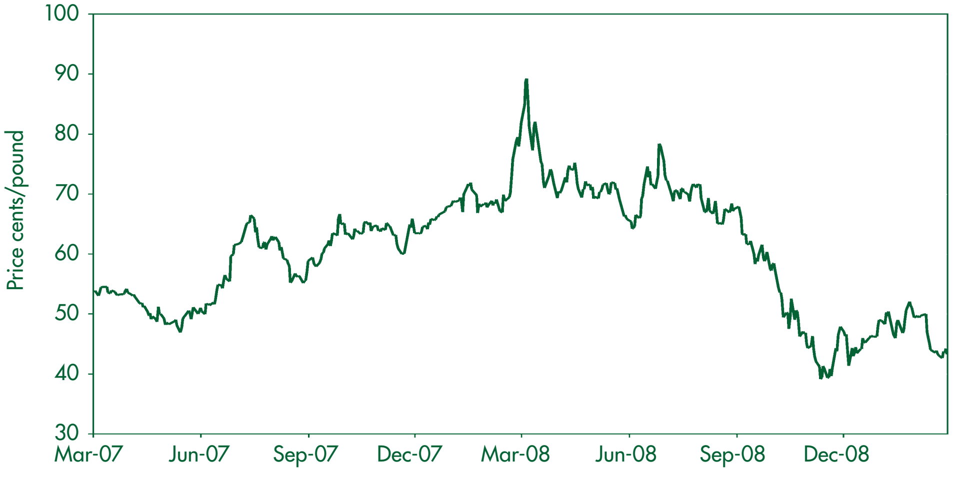
15, 2008. Like other merchants, Reinhart entered into forward contracts with growers in late 2007 and early 2008, hedging those purchases by selling futures. The run up in futures prices meant that Reinhart was faced with about $100 million in margin calls. On March 4, Reinhart closed their futures positions and entered into "various options trades" to try to maintain hedges in an effort to reduce margin risk and free up liquidity. But Reinhart incurred further losses on these trades, causing it to default on its loans.

Reinhart restructured its credit facility, giving its lenders increased control over its operations, and began to seek takeover bids. In July 2008, it obtained a bid from Allenberg Cotton that would ensure performance on its existing forward contracts, but the lenders vetoed this bid. In the meantime, cotton prices fell and Reinhart made significant gains on the short futures positions it established following its restructured lending arrangement. Reinhart states in filed bankruptcy papers that its lenders swept $180 million of these gains from its brokerage accounts. After being forced by its lenders to liquidate most of its futures positions in early October 2008, Reinhart filed for bankruptcy. Growers who held forward contracts with Reinhart are unsecured creditors in the bankruptcy proceedings; they may receive little or no compensation for their losses.

Implications for the Cotton Industry

The effects of the futures price spike on firms such as Reinhart, Dunavant, and Weil Brothers present new insights into extraordinary costs of using futures markets during unusual price activity. The Reinhart bankruptcy case provides evidence of how credit constraints can play out for hedgers, binding their operations. In this case, Reinhart was enabled by its creditors to nominally continue operations, but its existence was as a ward of its lenders.

Figure 3. Nearby Cotton Futures Price, March 2007–February 2009



Source: Commodity Research Bureau

The mark-to-market margining process of futures exchanges does ensure that the risk of a counterparty failing to honor their contract is minimized, but margin calls may require more cash than merchants have on hand. If the futures positions of cotton merchants were not marked-to-market daily, the gains or losses on their positions would be offset by gains or losses on their physicals, once realized. This would be the case if they used over-the-counter derivatives such as swaps to manage risk because swap contracts settlement is generally synchronized with cash market gains and losses.

While several cotton merchants have exited because of the price spike in March 2008, most of the long-term impacts will be borne by growers. The consolidation of large firms like Allenberg and Dunavant and the departure of other merchants means less competition and fewer options for forward selling. Even in California, the exit of firms due to events in the Upland cotton market means fewer marketing options for Pima cotton.

If cotton merchants continue to face higher costs and greater risk in using futures as a hedging tool, it is likely that they will require higher profit margins as compensation for bearing this risk. These higher margins manifest themselves to growers as weaker basis levels. Merchants may be less willing to maintain futures positions and may continue to offer fewer forward selling opportunities. The 2008 price spike for cotton suggests that risk management using exchange-traded derivatives may entail extraordinary costs that were not previously given much consideration. These costs may be relevant to the ongoing reform of derivatives regulation.

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