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Do Gasoline Prices Account for Ethanol's Lower Energy Content?

Firas Abu-Sneneh, Colin A. Carter, and Aaron Smith

U.S. law effectively mandates that retail gasoline must contain at least 10% ethanol. This artificial demand for ethanol drives up the price of corn, harming livestock operations and global food consumers. Recently, the U.S. government determined that short-term removal of the mandate would have no measurable impact on ethanol demand and, therefore, no impact on corn prices. If true, this ruling suggests motorists may be paying the same retail price for ethanol as gasoline, even though ethanol lowers fuel economy.

Also in this issue

In 2011 the United States consumed about 134 billion gallons of gasoline. An additional 13 billion gallons of ethanol was blended into that gasoline, as required by U.S. energy policy. At $3.50 per gallon, total consumer spending at the gas pump was approximately $515 billion in 2011.

Unlike in Brazil or Canada, where motorists are free to choose whether they burn ethanol in their engines, motorists in the United States are required to use gasoline that is blended with ethanol. The blending reduces fuel economy because ethanol produces about one-third less energy per gallon than gasoline.

One main reason the U.S. government requires ethanol blending is the strong political lobby of the corn farmers who now sell about one-third of their harvest into the fuel market instead of the food market. They also receive political backing from the renewable fuels industry.

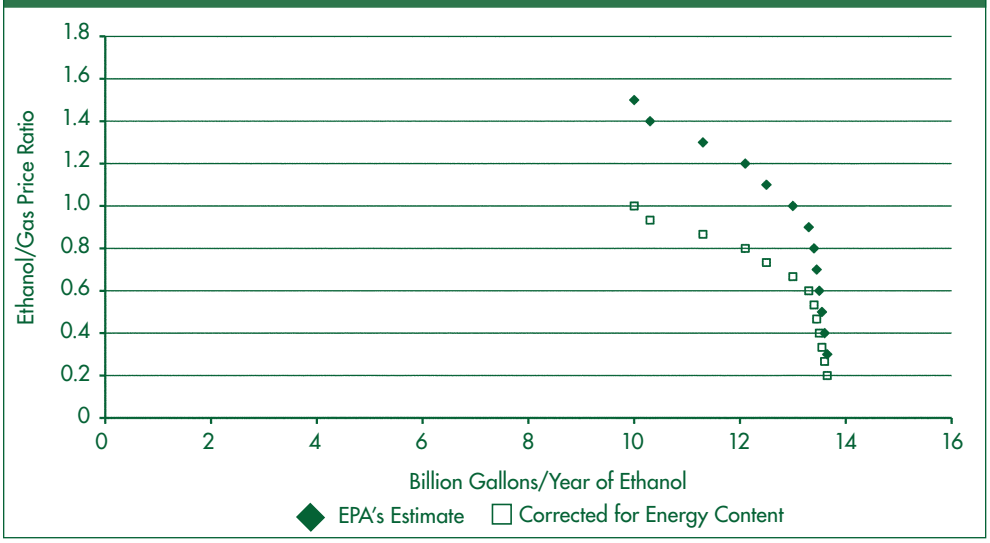
The acute 2012 drought in the Midwest lowered the U.S. corn harvest by about 28% from levels expected in June 2012, a supply shock of historical proportions. The drought had an unprecedented impact on corn prices because a large share of the harvest was already taken off the market by the ethanol program irrespective of the overall supply situation.

There is some scope to reduce ethanol production below mandated levels in a particular year by using credits accumulated by above-mandate production in the previous year. However, uncertainty about future ethanol policy, the desire to save these credits for future years, and the value of ethanol in a gasoline blend means that most of the demand rationing for the 2012–13 corn harvest was placed onto non-ethanol uses. This is the portion of the corn market that allows for supply and demand to work and, accordingly, the drought severely impacted the livestock industry and food consumers—especially those in less-developed countries.

The U.S. government could have potentially mitigated some of the effects of the 2012 drought by issuing a one-year waiver on the ethanol mandate, effective January 1, 2013, and then extended for one additional year in 2014. It was for this reason that several state governors petitioned the U.S. Environmental Protection Agency (EPA) to temporarily relax biofuel volume requirements under the renewable fuels standard–RFS. The governors, several members of Congress, and many firms and associations in the agricultural sector were asking the EPA to give the food markets some relief from record-high grain prices brought on by the drought.

But the EPA rejected the waiver request because it found the mandate is not causing severe economic harm. The EPA decision, announced

Figure 1. Estimated Ethanol Annual Demand Curve for 2012 and 2013



in November 2012, is not surprising because of the politics of ethanol. By law, the agency determined that it could only grant a relatively short-term waiver (one year) and the criterion for doing so was very stringent. It would have required the EPA to find that the RFS created "severe" economic harm in the short-run.

Demand for Ethanol by Refiners and Blenders

If the RFS had been waived, then refiners and blenders would have been free to choose how much ethanol to blend into gasoline. The decision would be driven by economics and motorist demand for ethanol, unlike the current situation in which they are forced to blend a certain annual volume.

Implicit in the EPA's recent ruling was a determination that the ethanol mandate is not binding in the short-run, which means the gasoline industry would continue to blend 10% corn ethanol into gasoline even if no longer required to do so. In other words, the EPA found that the demand curve for ethanol is relatively steep because refiners and blenders like to use ethanol even if they are paying more than its true market value. One reason they might like ethanol so much is that they can blend it into gasoline without dropping the price to allow for the fact that ethanol dilutes the energy value of the fuel.

Figure 1 reproduces the ethanol demand curve used by the EPA in arriving at their finding. The vertical axis in Figure 1 is the price ratio of ethanol to gasoline. Historically, the ratio of ethanol to gasoline prices has been around 90%, but it fluctuates with the prices of corn and crude oil. Until 2011 there was a tax credit for blending ethanol, which affected the ethanol to gasoline price ratio.

The demand curve used by the EPA is traced out by the solid diamonds in Figure 1. This curve assumes that, even if the price of ethanol were 40% more than gasoline, refiners and blenders would choose to blend 10 billion gallons of ethanol; at 20% higher prices, they would still blend about 12 billion gallons, which is close to 90% of the 2013 mandate. Therefore, as part of its ruling, the EPA decided that ethanol will be blended even if it is substantially more expensive than gasoline and there is no mandate. This is unlikely.

In Figure 1 we draw an alternative demand curve that adjusts for energy content, which is traced out by the hollow squares in Figure 1. This demand curve starts to bend to the left once the ethanol/gasoline price ratio rises above 0.7 because ethanol has only two-thirds the energy content of gasoline.

We believe the finding that a RFS waiver would have a relatively small impact on the demand for ethanol for blending was partly due to the EPA's assumption that gasoline is sold on a volume (and not on an energy) basis. This implies it is profitable for the industry to "cut" gasoline with ethanol as long as ethanol is cheaper than the gasoline blendstock (BOB)

The EPA apparently assumed that once ethanol is blended into gasoline, then consumers get no discount for the reduced energy content. In other words, they assumed that motorists are being fooled because they do not realize that it takes 1.53 gallons of ethanol to equal a gallon of gasoline, based on BTUs of energy in a gallon.

We submitted a comment to EPA while they were reviewing the waiver request. In that submission, we argued that a waiver would have an impact if finished gasoline is priced lower when it contains ethanol compared to when it has zero ethanol. One of the EPA's published comments on our submission was: "we did not see evidence presented in this study to change our reasoning with respect to how ethanol is priced." (Fed. Register, 77, No. 228, Nov 27, 2012, p. 70767).

If true, this EPA assumption has stunning consequences as it suggests there is a large hidden cost associated with the ethanol mandate. Most consumers and businesses pay close attention to the amount of money they spend on transportation. If the cost of driving were to increase due to lower energy content in gasoline, then some motorists would reduce their demand for fuel and the price would decline.

This assertion holds for E85, which is a motor fuel that contains up to 85% ethanol. The fact that E85 usually sells at a discount to regular gasoline reveals that consumers determine their fuel demand based partially on energy content. It is also the case that

E85 is not popular with motorists.

But consumers do not have a choice today because aside from E85, which has a very small market share, the volumetric mandate effectively requires refiners and obligated parties to produce and market only motor fuel with 10% ethanol (known as E10). In ongoing research, we are presently analyzing market data to test whether the price of E10 reflects energy content.

What if the EPA is right and consumers do not get a discount to reflect the lower mileage of fuel with 10% ethanol compared to gasoline with zero ethanol? In that case, the RFS conventional biofuels mandate is severely harming consumers by enabling gasoline producers/distributors to sell an inferior product (blended gasoline) at the same price as uncut gasoline. And motorists are required by law to purchase the blended fuel even if it is not priced competitively.

The True Value of Ethanol

Estimating the true value of blended gasoline will help establish the true demand curve for ethanol for purposes of determining the economic welfare effects of the mandate. To estimate the value of ethanol, we constructed a linear programming model of gasoline blending.

As a blending component, ethanol's main advantages lie in its relatively high octane rating and its lower price per volume. On the other hand, ethanol has high volatility, lower energy content, and higher distribution costs because it cannot be transported by pipeline.

Our model minimizes the total cost of producing a gallon of gasoline equivalent (GGE) subject to achieving a minimum octane rating and a maximum Reid vapor pressure level (RVP), which is a common measure of a fuel's volatility. We restrict ethanol content to be no more than 10% of gasoline volume, which is the maximum amount of ethanol that most of the U.S. vehicle fleet can handle without causing serious damage to the engine due to the corrosive nature of ethanol. To account for the possibility that gasoline is priced by volume rather than energy content, we also use our model to find the minimum cost formula for producing a gallon of fuel by volume without regard for energy content.

Figures 2 and 3 show the key results from our model for summer and winter gasoline blends (accounting for different RVP maximum levels). The vertical axis in Figures 2 and 3 is the price ratio of ethanol to gasoline, and the horizontal axis is the price ratio of octane enhancers to gasoline. In each figure there are two upward sloping lines. In the area below the lower upward sloping line, it would be profitable to blend ethanol at the maximum 10% (8%) in the summer (winter). Currently, both the winter and summer fuels are blended at the 10% ethanol level (i.e., E10) because the federal mandate requires the nation to use a fixed volume of ethanol.

In the absence of the mandate, winter fuel would most likely have less ethanol than summer fuel because the allowed RVP maximum is higher in the winter. This would permit the addition of more butane, which has high octane and is attractively priced, but cannot be used extensively in the summer due to its high RVP.

The area between the two upward sloping lines represents a region in the price grid where blending makes economic sense only if the blend is sold on a volume basis rather than on its energy content. Finally, above the top

Figure 2. Threshold Prices for Ethanol to be Profitable in Summer

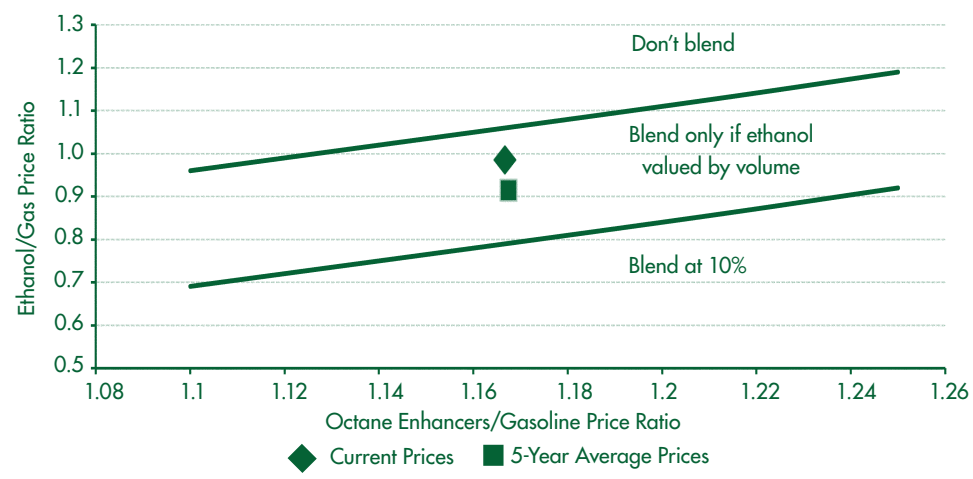
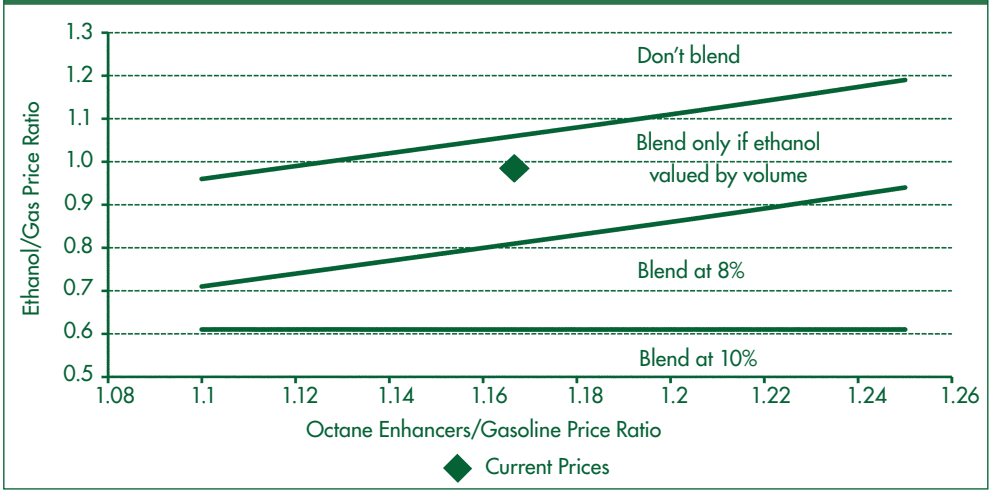
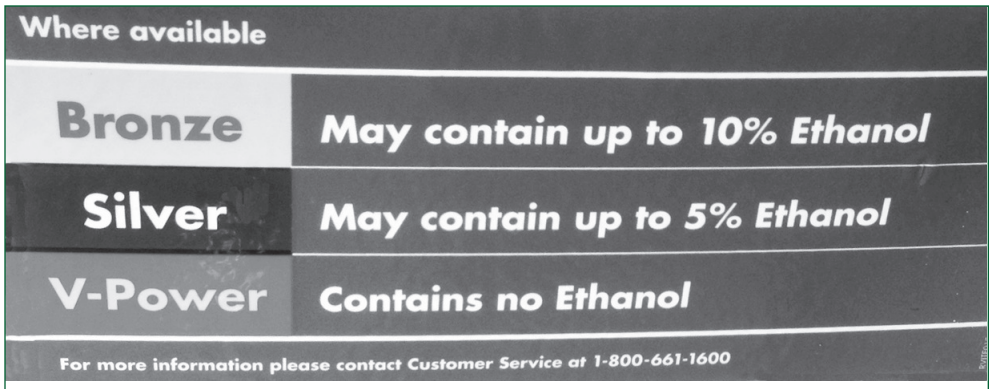


Figure 3. Threshold Prices for Ethanol to be Profitable in Winter





Gas pump in Canada where unlike in the United States, motorists have a choice regarding ethanol percentage. V-Power is the premium high-octane gasoline.

line, blending ethanol is not optimal.

In Figures 2 and 3, the diamond represents the approximate point where the market is now—with wholesale gasoline at $2.41, the price of octane enhancers around $2.81, and ethanol at $2.38. It is clear that if retail (blended) gasoline were valued on energy content, it wouldn't be optimal to blend at the present time because the diamond lies above the bottom upward sloping line in each figure.

On the other hand, if we don't account for the energy content of ethanol, which means that blenders are able to "cut" gasoline with ethanol and, in essence, "fool" consumers, then it would be optimal to blend. In this situation, consumers lose because they do not receive a discount for the blended fuel, even though it gives them lower mileage.

How unusual is the current environment? Ethanol prices currently are high due to high corn prices, but crude oil prices are also relatively high at about $90 bbl. for WTI crude and $110 bbl. for Brent crude.

What if ethanol and gasoline prices return to their 5-year average values of $2.02 and $2.21 per gallon, respectively? Then we will have a situation similar to that shown by the solid square in Figure 2, which represents 5-year average prices. We see that the square lies between the two threshold lines, indicating blending would not be profitable if gasoline was priced on an energy basis.

If the EPA is correct and there would be no market response to a temporary reduction in the mandate, then gasoline consumers are effectively absorbing the economic cost associated with lesser fuel economy. This is a hidden cost of the ethanol program and a wasteful, inefficient tax on motorists.

Our model shows that E10 is priced above its minimum-cost GGE by approximately 0.9% in the summer and 0.6% in the winter. This mispricing comes at a direct cost to consumers, which we estimate costs them $3.5 billion per year, or 2.63 cents per gallon.

Who reaps the benefits from ethanol being overvalued in this way? Because ethanol is usually blended at the terminal level, refiners may or may not see this benefit. The blenders may collect some of this profit, or possibly it is bid away into the price of ethanol, further benefitting the ethanol industry.

If refiners do not receive the blending profit then ethanol provides them with less economic benefit and it imposes an opportunity cost in the form of lower utilization of existing refinery capital. In this scenario, refiners would have a greater incentive to respond to a waiver by reducing ethanol use.

Conclusion

Implicit in a recent decision by the U.S. Environmental Protection Agency (EPA) is the conclusion that the ethanol mandate costs U.S. motorists about $3.5 billion per year by allowing refiners/blenders to cut gasoline with lower-valued ethanol without adjusting the price of the blended product. Ideally, motorists should be free to choose between no ethanol or some blend of ethanol in their gasoline. This would reduce costs to motorists, allow refiners and blenders to choose to blend less ethanol when the corn harvest is low, and blend more ethanol when the harvest is abundant.

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For additional information, the authors recommend:

Energy Policy Research Foundation Inc. (EPRINC) "Ethanol's Lost Promise" Washington DC. Sept. 2012. http://eprinc.org/pdf/EPRINC-ETHANOL-LOSTPROMISE-2012.pdf

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Identifying Factors That Contribute to High Rates of Obesity in Mexican-Origin Children

Adela de la Torre, Richard Green, and Lucia Kaiser

Alarming overall high rates of the body mass index (BMI) were found in our BMI measurements of 108 mothers and children in the Mexican-origin population. Baseline data from Mexican-origin mothers and children in Firebaugh and San Joaquin, CA indicate several factors that contribute to the high rate of obesity in this population. One factor that should be further explored is the potential impact of high food insecurity on nutritional decision-making in these families.

During the last 30 years, the rate of obesity among adults in the United States has increased at unprecedented rates. However, the rate of growth of obesity is not equally distributed across populations and age groups, suggesting that there may be different factors underlying the behaviors associated with this growing health problem.

Moreover, another alarming and emerging problem is that childhood obesity rates are also increasing. In 2009–2010, approximately one in six U.S. children and adolescents were obese and the prevalence of obesity disproportionately affected Latino and African American children. For example, over one in five (21.2%) of Latino children and adolescents and almost one and four (24.3%) non-Latino black children and adolescents were obese compared to less than one in seven white non-Latino children and adolescents. These differences across groups suggest a need to better define the underlying factors of childhood obesity across groups to develop strategic and sustainable interventions.

California, with the largest Mexican-origin population in the United States, is uniquely situated in providing researchers an ideal environment to identify risk factors influencing the high rates of childhood obesity in this population, as well as testing innovative interventions. The unique partnership between UC faculty and UC Cooperative Extension allows for building on existing partnerships in rural communities to expand and enhance nutritional educational information to many isolated towns with this population. Both these factors provided an important comparative advantage that led eventually to U.S. Department of Agriculture (USDA) funding a $4.8 million, 5-year study in 2011, focusing on preventing the rate of growth of childhood obesity among Mexican-origin children.

Situated in California's Central Valley in the rural agricultural towns of Firebaugh and San Joaquin, Niños Sanos, Familia Sana (Healthy Children, Healthy Family), is a multifaceted intervention study funded by the USDA National Institute of Food and Agriculture. The project provides a unique opportunity to test the impact of fruit and vegetable vouchers on consumption patterns on childhood obesity rates of low-income Mexican-origin families with children between the ages of 3–8 years of age. It also includes nutrition and physical education interventions targeting these families and their children.

The preliminary baseline data from this study gives not only a profile of this population, but also a glimpse of the complexity of the risk factors associated with high rates of childhood obesity within the Mexican-origin population.

Baseline Data

The study design for this experiment can be described as quasi-experimental, with two communities that have very similar demographic and occupational characteristics. In addition, the target communities were selected as they were situated in the nation's poorest Congressional District, CD 20, according to the U.S. Human Development index.

We were also interested in not only targeting a specific ethnic group, i.e., Mexican-origin, but also one where there was no active and ongoing obesity prevention program. Figure 1 below provides the relative proximity of San Joaquin and Firebaugh within the Central Valley.

During our baseline data collection period, we obtained informed

Figure 1. Location of the Obesity Design Study

Table 1. Mother's Acculturation Data	
Country of Birth (% from Mexico)	90.2%
Ethnicity: Mexican-origin, Chicana	99.0%
Language: (% Spanish only)	84.2%
Years in U.S.	13.6 yrs
Age Entered U.S.	21.3 yrs
Country of Education: (% in Mexico)	73.8%

consent and collected the following medical measurement data from participating families: height, weight, waist circumference, and skinfold thickness. We also collected a number of surveys to obtain background information about participants.

We collected a household survey which included information on demographics, household structure, decision-making, neighborhood conditions, income, expenditures, and assets. We also administered questionnaires targeted at medical history, food consumption frequencies, food insecurity, and acculturation.

Although all parents or guardians were eligible to participate both in the medical measurement and surveys with their children, in general, the female head of household completed most surveys for her household—over 97%. This resulted in the adult data being provided primarily by the mothers of eligible children in this study.

This bias in response and measurement can be attributed to two important factors: (1) most female participants did not work outside the home on a regular basis and, hence, were more accessible, and (2) cultural factors within the Mexican-origin community, where "women" in general are more engaged in practical aspects of health and the well-being of their children.

As we can see from Table 1, 90.2% of the mothers in our study were born in Mexico and 99% identify as Mexican-origin. The average age for this sample was 35 years and their duration in the United States was well over a decade. Nonetheless, most of these women primarily spoke Spanish—84.2%.

Figure 2 provides an overview of the overall level of educational attainment of both the mothers and fathers in this study. These data reveal that for many of these women, the level of educational attainment is quite low: 26.8% completed high school, and 23.4% only completed an elementary school education.

On average, these families earn $1800/month when they are employed. However, it is important to note that most of the families are employed in highly seasonal labor and have months with no income. Among the adults in the sample, 63% percent of fathers are farm workers and 65% of mothers are homemakers. These baseline data capture the employment season.

BMI Rates

What is most alarming in our preliminary data are the overall high rates of Body Mass Index (BMI kg/m2) for the mothers and children in our study. Based on the 108 BMI measurements of participating mothers in the study, the average BMI was 31.1. However, within the sample, almost one-half were defined as obese and slightly over 86% were either overweight or obese. Adult men and women are considered overweight if their BMI is between 25 and 29.9. They are considered obese if their BMI is 30 or greater.

For children, since they are still growing, ideal BMI measures are more complicated to define. BMIs are compared to growth references for children of the same age and gender. Children are considered overweight if their BMI is equal or greater than the 85th percentile and obese if their BMI is equal or greater than the 95th percentile.

Thus, compared to the general U.S. population and Mexican-origin

Figure 2. Educational Attainment of Mothers and Fathers in Sample

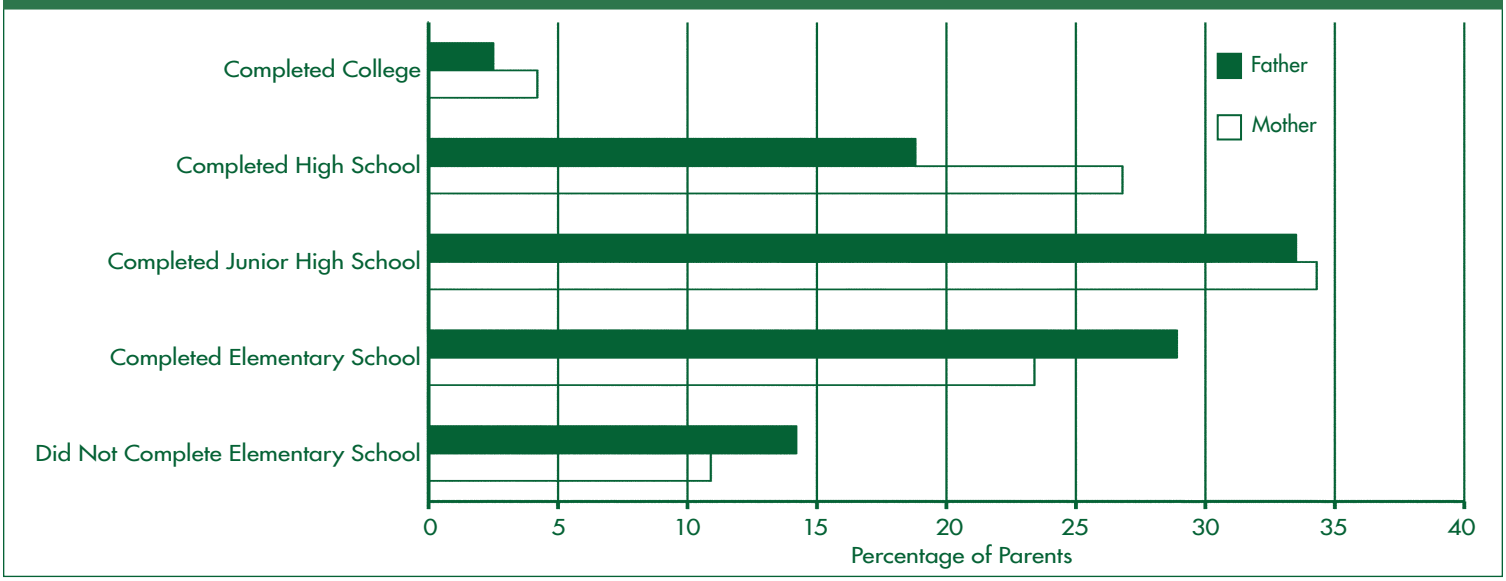
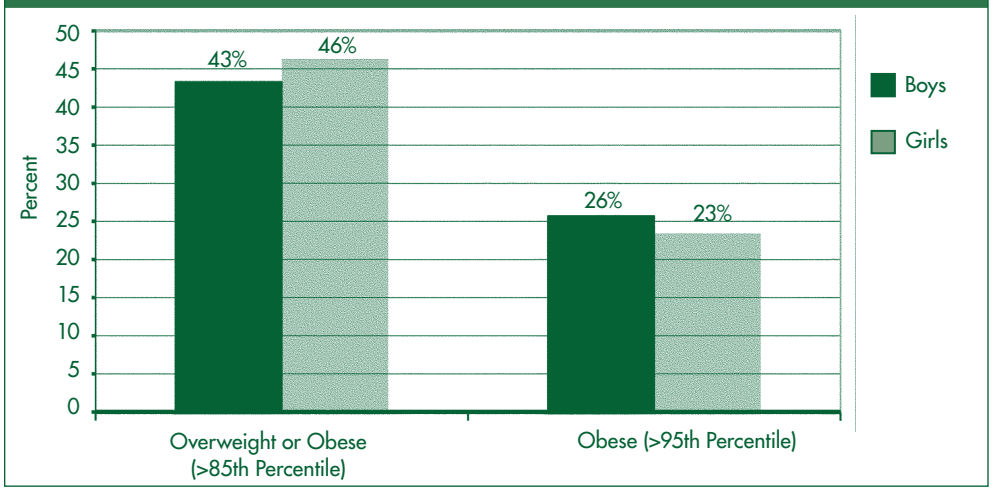


Figure 3. Percentage of Overweight and Obese Mexican-Origin Children



population, these women had a considerably higher rate of overweight and obesity status. Similarly, when examining their children, a pattern emerges of relatively high rates of overweight/obesity within this population. See Figure 3 for the distribution of overweight and obese children in the Mexican-origin population in our sample.

Food Security and Obesity

An important survey instrument used in our study was the 18-item USDA Food Security Survey (available on the Economic Research Service website). This instrument is used annually in the Current Population Survey to monitor household food security in the United States. The validity and reliability of this instrument is well-established in U.S. populations, including Mexican-origin households.

An interesting finding in our baseline data is that 37% of our sample indicated that they were food insecure (with 13% reporting very low food insecurity), which can generally be interpreted as meaning children and adults are very likely to be skipping meals due to low food access. In addition, 84.3% indicated that they participated in either food stamps and/or WIC, so they are indeed active participants in these programs.

Thus, an alarming risk factor that should be further explored is the potential impact of high food insecurity on nutritional decision-making of these families. This high level of food insecurity may impact the observed overweight/obesity rates in this population.

Although our data is preliminary, other studies in Texas and California provide some support of the adverse impact of food insecurity on healthy food choices for Mexican-origin families.

Conclusion and Policy Implications

Based on our preliminary data, in addition to risk factors such as income and education that may influence relative overweight/obesity rates within rural Mexican origin communities, food insecurity may be an additional factor to consider in designing interventions for this population.

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The Changing Landscape of National-Scale Droughts

Steven Wallander and Jennifer Ifft

The 2012 drought is meteorologically similar other national droughts of the past century. This year, however, a variety of factors—such as crop insurance, strong commodity demand, greater conservation tillage, and improved crop genetics—helped to reduce the negative impacts.

The 2012 U.S. drought provided a stark reminder that some droughts are national in scale and that agricultural production is particularly vulnerable to drought. Taking a geographic approach, we define a "national-scale" drought as one for which over 50% of agricultural land is exposed to moderate or greater drought. Over the past 118 years, the U.S. has experienced about nine national-scale drought years (Figure 1), some of which occurred within mutli-year droughts such as the Dust Bowl.

In this article we examine several factors that influence the farm-level economic impacts of national droughts. We examine the 2012 drought's uniqueness among historical national droughts by identifying key differences.

Drought Severity, Extent and Vulnerability

Drought is a shortage in water availability, but comparing one drought to another requires being very specific about what sort of water is relevant—precipitation, surface water storage, soil moisture, etc.—and the time period over which the shortage occurs. In addition, because of regional differences in average water availability, some normalization to long-run average local conditions is required. One farmer's drought may be another farmer's flood.

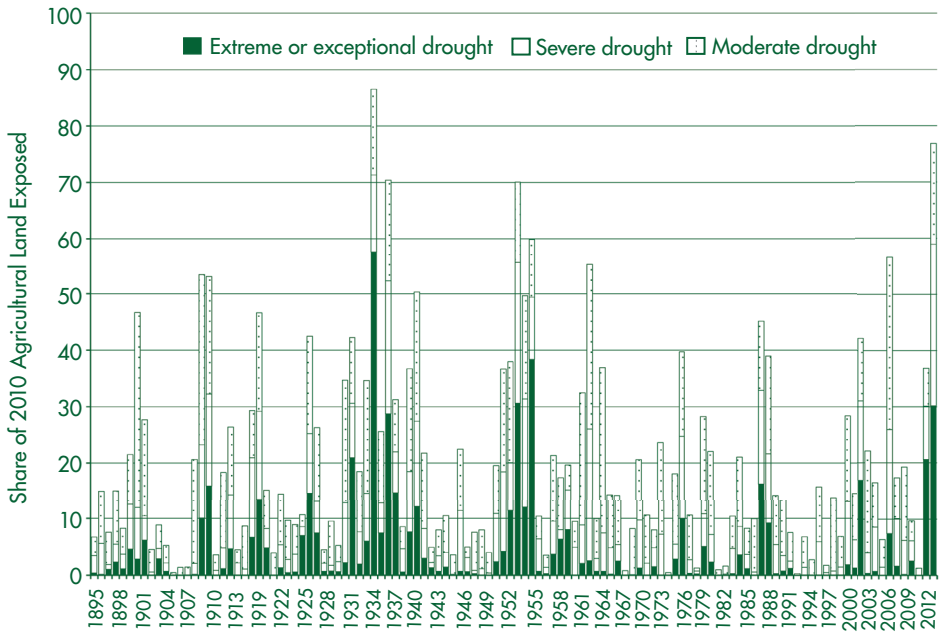
Meteorologists have developed drought indices that convert weather data—such as monthly precipitation totals and temperature averages—into measures of drought severity. For our purposes, the Palmer Modified Drought Index (PMDI) provides a good measure with which to compare drought severity over time. Under the PMDI, droughts are categorized as moderate, severe, extreme, or exceptional depending upon how far they deviate from average conditions in a given location.

Not surprisingly, the peak of the Dust Bowl, in 1934, was the most extensive and severe drought on record in the U.S. (based on weather records that begin in 1895). In 1934, about 85% of agricultural land experienced moderate or greater drought. Perhaps more surprisingly, 2012 was almost as bad as 1934. In 2012, about 75% of agricultural land was experiencing moderate or worse drought.

Drought location also matters. Some agronomists and agricultural economists consider the 1988 Midwest drought to have been more severe and of greater national significance than the 2012 drought. One reason is that the 1988 drought hit a greater proportion of the Corn Belt than the recent drought. Another reason is that by more short-term measures (such as the Crop Moisture Index, or CMI) the 1988 drought was empirically of greater severity. While these relative rankings are somewhat sensitive to a number of measurement issues, there is no doubt that 2012 ranks among the worst agricultural, national droughts of the past century—at least meteorologically speaking.

Of course, drought severity, or more precisely exposure to severe drought, is only part of what determines drought impacts. The other part is drought vulnerability.

Figure 1. Exposure of Agricultural Land to Drought



Source: USDA ERS calculations based upon NOAA station-level PMDI records that were interpolated to county centroids and assigned to agricultural land area as measured in the 2010 Agricultural Resource Management Survey (ARMS).

Vulnerability is the sensitivity of impacts to levels of exposure.

Although it is still too early for a full accounting of the 2012 drought impacts, we already know that the 2012 drought is unlike any previous national-scale drought in terms of vulnerability. There are at least three reasons for this: 1) agricultural policies, particularly crop insurance; 2) price responses, particularly given sustained demand drivers; and 3) production practices that influence vulnerability.

Policy Differences in 2012

Major droughts have a history of impacting agricultural policy. The Dust Bowl led to the creation of the Soil Conservation Service (predecessor to today's Natural Resources Conservation Service) as well as numerous other aspects of agricultural policy. The 1988 drought, and the ad hoc disaster assistance provided by Congress in response, created the motivation for major changes to the crop insurance program in the 1994 Federal Crop Insurance Reform Act and the 1996 Farm Act. There may be policy changes that arise from the 2012 drought, but current indications are that the 2012 drought is unique in the extent to which agricultural policies helped to dramatically reduce the vulnerability of farms to drought impacts.

Crop insurance is arguably the most significant change since previous national droughts. While some form of crop insurance has been a part of agricultural policy since the Dust Bowl, the effectiveness of the program at reducing vulnerability only really took hold within the last two decades. The main reason for this has to do with voluntary participation decisions by farmers and the extent to which policies incentivize that participation.

Federal crop insurance works by providing premium subsidies (and other subsidies) to encourage farmers to purchase crop insurance from private insurance companies that will guarantee some minimal portion of the farmers' expected crop revenues. Some insurance policies are only triggered by yield losses, generally due to factors such as drought, floods, frosts, pests or any number of other "perils." Other policies provide additional protection against revenue losses due to drops in crop prices.

There are a number of different crop insurance products that differ in how expected yields and prices are calculated and how indemnities are triggered, and the menu of available insurance products has changed considerably over the past two decades. For our purpose, the most important changes have to do with farmer participation in the program. As farmers have elected to enroll more acreage and to buy higher levels of coverage, the share of expected crop revenue that is insured has increased dramatically.

For example, we calculated the aggregate coverage rate for corn between 1989 and 2012 by multiplying the average coverage rate for insured corn acreage times the share of planted corn acres that has insurance. The result (Figure 2) shows that the aggregate coverage rate for corn has increased from 20% in the early 1990s to about 60% in the past few years. This places a significant floor on the damages to crop revenue that occur in response to a given national drought. We should note that some other crops, and other sectors such as livestock, are not as well-insured as corn.

Price Response in 2012

The relative strength, or elasticity, of commodity demand plays a large role in drought vulnerability since it determines how much negative yield shocks will be offset by price increases. Demand for crops is generally inelastic, indicating that when a supply shock such as a major drought occurs, the decrease in output is proportionately less than the increase in prices. This can cause large increases in prices in response to even relatively small declines in supply.

In 2012 prices for corn, soybeans and other commodities increased dramatically. Since crops are traded in a national market, the higher prices provided some relief for farms with major (but not total) yield losses. Price increases almost perfectly offset moderate yield losses and provided a boost in revenue for those farms with close to expected yields.

Historically, prices have not always increased during droughts; the broader economy also plays a role. During the Dust Bowl, commodity demand had already weakened considerably due to the Depression. Producers faced not only declining yields but also weak demand.

The 2012 drought is notable for the demand conditions facing farms, particularly crop farms. Two major factors make 2012 commodity demand unlike previous national droughts. The first is growth in biofuels demand. Notably, corn ethanol production increased dramatically from the 1990s, and now uses over one-third of all U.S. corn production. Perhaps even more importantly in terms of drought vulnerability, the high gasoline prices and renewable fuels mandates that encourage ethanol demand arguably make aggregate corn demand much more inelastic. The second factor is increasing food demand from developing countries, especially India and China. As incomes increases, consumers demand more meat. This, in turn, increases livestock production and drives up grain demand.

The price impacts of the drought have led to farm sector income being forecast to hold steady in 2012, only declining slightly below 2011. This is not unprecedented; net farm sector income increased slightly in 1988. Income for the average farm business that specializes in major field crops is

expected to increase, while some farm businesses that specialize in livestock production are forecast to experience declines in income. While crop producers are expected to benefit from insurance indemnities and high prices in 2012, livestock farm income appears to be more vulnerable to drought impacts due to increasing feed prices.

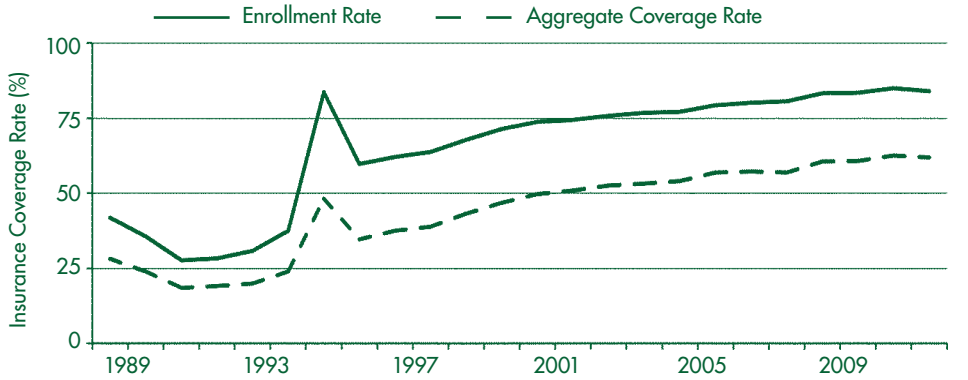
Production Practices in 2012

Beyond crop insurance and market-level reactions, the 2012 drought was also a unique national drought due to changes in crop production practices. Recent research suggests that drought vulnerability, measured as the sensitivity of crop yields to drought of a given magnitude, has been decreasing. While this research focused only on a few states and looked primarily at moderate drought, if these results hold for other states and for the severity of the 2012 drought, then there will be growing interest in determining exactly what has changed to reduce yield vulnerability.

One line of argument suggests that crop genetics have improved drought tolerance. A number of new drought tolerant corn varieties are now entering the seed market, but these are not yet widely planted. A more likely explanation is that selection for greater yields has come, in part, through improved water use efficiency, which is not the same as drought tolerance but is very closely related.

Another line of argument suggests that meteorological droughts, as measured by precipitation and temperature-based indices like the PMDI, do not accurately measure changes in soil moisture availability. One reason would be that no-till and conservation tillage has increased dramatically over the past two decades, in part in response to the availability of herbicide-tolerant seed varieties. Conservation tillage has the effect of reducing soil moisture loss, particularly during higher temperature periods.

Figure 2. Aggregate Insurance Coverage Rate for U.S. Corn



Notes: The "enrollment rate" is the share of corn acreage enrolled in each year, which is calculated as the net acreage enrolled in insurance (USDA, RMA) divided by the total planted acres (USDA, NASS). The "aggregate coverage rate" is the enrollment rate times the acreage-weighted average coverage rate (USDA, RMA).

A variety of other factors also influence drought vulnerability. Planting times are now occurring earlier, which moves the sensitive plant development stages earlier in the season. Due to a prolonged period of high commodity prices and low interest rates, the farm sectors debt to asset ratio is at a historic low, which reduces the risk of debt default due to drought.

Lastly, there have been some increases in supplemental irrigation as well as improvements in irrigation efficiency, which reduce water losses. Any of these factors could have been important in some of the regions impacted by the 2012 drought.

In conclusion, the 2012 drought was a major negative shock for U.S. agricultural production. For some farms and for some regions, the 2012 drought was a crisis. However, despite being meteorologically similar to earlier national droughts, it appears that the 2012 drought was not as damaging to the national agricultural economy as previous droughts and there are many reasons why this is the case.

An important challenge for looking forward—to the possibility of increasing drought risk under many climate change scenarios—is determining whether drought vulnerability in the future will look like the 2012 drought, the 1934 drought, or like something entirely different.

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For additional information, the authors recommend:

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