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Drought, Jobs, and Controversy: Revisiting 2009

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The effect of the 2009 water shortage on San Joaquin Valley agricultural jobs was a contentious topic which was exacerbated by conflicting job-loss estimates. In hindsight, econometric analysis of payrolls for employment and satellite data on crop fallowing have provided a clear measure of the extent of job losses in the San Joaquin Valley. However, droughts will occur again, and forecasts will have to be made. This paper presents the forecasts made, analyzes the reasons for differences in the forecasts, provides a final estimate of job losses, and draws insights for meaningful forecasts in the future.

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In 2009 California was in the third year of severe drought, and legal rulings had further limited water deliveries to agriculture in the San Joaquin Valley. Water users, farmers, and policymakers were interested in the effects of drought and additional water restrictions. Using data from state agencies, we forecasted the changes in agricultural production, revenue, and jobs due to water shortage in the San Joaquin Valley.

Beginning in January 2009, and followed by updates in May 2009, September 2009 and September 2010, a series of reports were released with updated acreage, revenue, and job-loss estimates. The dates of the reports were tied to updates in anticipated water deliveries released by the California Department of Water Resources (DWR) and United States Bureau of Reclamation (USBR).

In each report, the most recent estimates of announced State Water Project (SWP) and Central Valley Project (CVP) deliveries and groundwater pumping capacity were used to forecast the economic impacts of reduced water supply. As water deliveries increased, estimates of losses in agricultural acreage, revenue, and jobs were decreased. In other words, the water-cut scenarios were driving the job-loss forecasts.

Our January 2009 report contained a technical error, which we corrected as soon as it was brought to our attention by several colleagues, but has subsequently generated significant confusion. We want to clarify what this mistake was and how we corrected it.

We first used changes in agricultural water deliveries to forecast changes in irrigated acres and farm revenue using the Statewide Agricultural Production Model (SWAP). These losses in revenues were then combined in a regional input-output model to estimate job losses. An error occurred in this second step.

Our January 2009 estimates used the REMI input-output model, and we failed to notice that the "multiplier" used to translate losses in agricultural revenue into job losses was nearly double an acceptable value. In general, one million dollars in lost farm revenue translates into a range of 15 to 28 direct agricultural jobs lost. Our January 2009 estimate used 39 lost jobs per one million dollars in lost revenue. To correct this error, we purchased and calibrated a more transparent input-output model, IMPLAN, which we have used for all subsequent analysis.

In 2009 California was at the peak of the recession, and job-loss estimates generated significant attention. Adding to the confusion, preliminary monthly job surveys from the California Employment Development Department (EDD) showed agricultural employment in the San Joaquin Valley was largely unchanged between 2008 and 2009. Consequently, some partisan groups incorrectly stated that there were no jobs lost due to water shortage in the San Joaquin Valley.

There are two problems with using preliminary employment survey data to forecast job losses. First, the preliminary data are prone to survey error, which we have discussed in other reports, and are subject to revision. Although the initial estimates showed no change in jobs, the revised estimates, released nearly a year after the drought in 2010, showed 9,800 agricultural jobs lost in the San Joaquin Valley.

Second, and more important, a change in month-over-month employment across years does not provide a basis to assert causality, and is difficult to interpret due to the likely presence of confounding factors. Finally, we note that surveys are not useful in forecasting because they rely on observed (i.e., past) data.

Agricultural production forecasts using the SWAP model rely upon a deductive method to estimate production and revenue changes due to water shortage. When linked to a properly specified input-output model, job losses can also be forecasted. While the payroll data provide a valuable retrospective benchmark, they arrive too late to influence current water policy, which requires forecasts of job and income impacts in real time.

In this article, we review the job-loss estimates based on SWAP and IMPLAN model results, and compare them to EDD job-loss surveys, and show how changes in water deliveries changed forecasts. We conclude by discussing the usefulness of SWAP for forecasting drought effects and compare results to a recent econometric analysis.

Forecasting Agricultural Production: An Overview of SWAP Estimates

SWAP is a mathematical model of California agriculture which exactly replicates a base year of input use and crop production. When faced with water shortages, farmers respond by fallowing land, deficit irrigating crops, pumping additional groundwater, and shifting to less water-intensive crops. All of these activities reduce agricultural profits. Additionally, groundwater is the most expensive source of water in most regions, thus additional pumping further reduces profits. Fundamentally, agricultural production modeling is based on a clear causal link between water and acres, and acres and revenue. Revenue is then linked to jobs using the IMPLAN input-output model.

We published four forecasts based on the SWAP and IMPLAN models, including three during the drought in January, May and September 2009, and a retrospective assessment in September 2010. We used the most accurate water-supply information available at the time, from the SWP and CVP, regional groundwater pumping capacities and regional local surface water supplies, to produce each forecast. We used this information to forecast the expected change in agricultural production and, as water deliveries increased and late season rains occurred, forecasts of impacts decreased.

The first forecast was released in January of 2009 by Howitt, MacEwan, and Medellin-Azuara. At the time, the best available data forecasted CVP and SWP deliveries of zero and 10%, respectively, with local surface supplies at 1991 levels. Data on groundwater pumping capacity was not available at the time, thus we ran the model over a range of capacities between zero and 100% pumping increases. The combined effect was an average total water shortage to the entire San Joaquin Valley of 29%. We estimated revenue losses in the San Joaquin Valley between $1.4 and $1.6 billion, with between 650 and 700 thousand acres fallowed. The corresponding estimate of job losses fell between 30 and 40 thousand.

Howitt, Medellin-Azuara and Mac Ewan released a second forecast in May of 2009, and a third forecast in September 2009 with more technical details. Between January and May, SWP and CVP water deliveries were increased from zero to 40% and 10% of normal, respectively. DWR completed an analysis of groundwater pumping capacity and found that some regions in the San Joaquin Valley could increase pumping, in the short term, by up to 400%—well in excess of previous estimates. The combined effect was a total water shortage to the entire San Joaquin Valley of 21%. We estimated revenue losses to be $710 million, with less than 450,000 acres fallowed. The corresponding estimate of job losses was 21,000.

Michael et al. released a fourth report in September of 2010. In this analysis, we had the luxury of observing the actual water-supply situation in 2009. The most striking finding was that over 500,000 acre-feet of known water transfers took place in 2009, which served to significantly offset some of the localized effects of the drought. Additionally, east-side local surface water supplies were higher than the anticipated 1991 levels due to late season rains. The combined effect resulted in water-supply reduction of 11%, about half of the best available predictions for the last forecast estimate in September 2009. As a result of the better-than-anticipated water supply, revenue losses, fallowed acres, and job losses were lower than previously forecasted. We estimated revenue losses of $370 million, with less than 270,000 acres fallowed. The corresponding estimate of job losses was 7,500.

An Overview of EDD Surveys

EDD uses a two-part process to collect farm employment data. During the year, they perform monthly surveys which are finally verified a year later when payroll data become available. Employment surveys serve as an important benchmark for retrospectively checking the accuracy of forecasts. Comparing monthly changes in jobs across years may estimate the change in employment, but not the reason why the number of jobs changed.

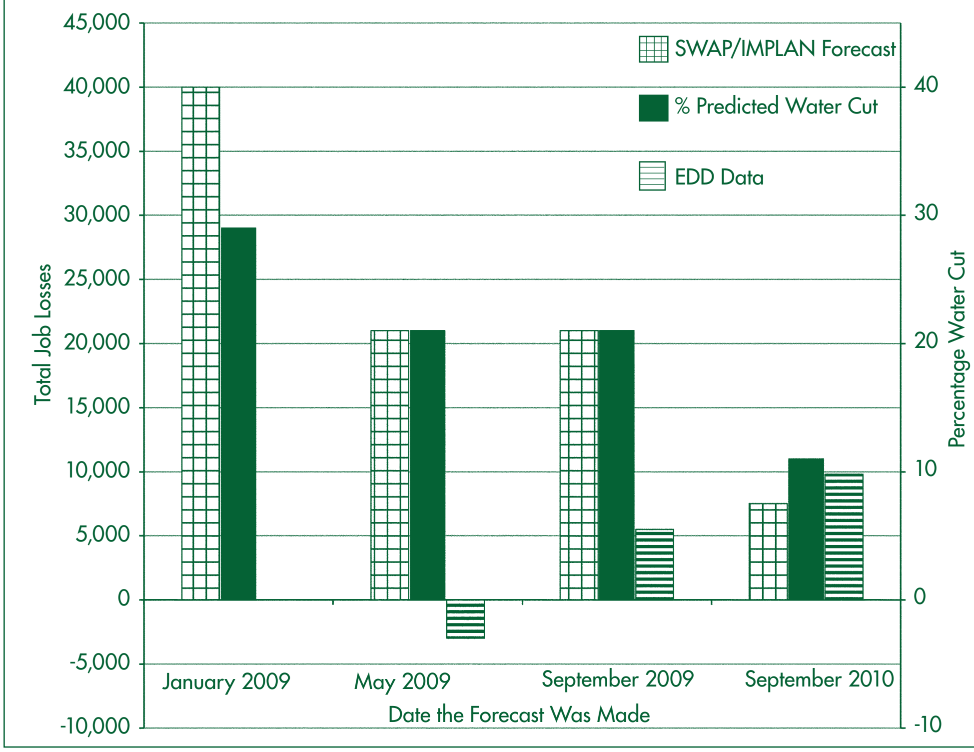
The California EDD releases monthly surveys of jobs across industries in California, and we focused on total agricultural jobs in the San Joaquin Valley. Initial survey releases showed significant positive job growth in agriculture during 2009, even when fallowing was increasing and the drought was anticipated to be worse than realized. EDD surveys are the product of a constant sampling procedure that is subject to significant bias if the sampling frame is changed by outside factors.

According to the EDD, if someone worked for an agricultural employer for any period, longer than one hour, during the week that contains the 12th day of the month, the EDD counts that person as an employed farm worker for that month. This method will work well, as long as there are no rapid changes in the pool of potential workers.

However, farm worker supply increased in 2009 due to a downturn in construction, and at the same time worker demand decreased due to drought, thereby increasing competition for existing agricultural jobs. Due to the seasonal nature of farm jobs, this translated into shorter periods of employment. For example, with extra workers available, a farm manager who might have hired one worker for three days may instead hire three workers for one day. Consequently, total employment as reported by EDD would increase from one worker to three workers for that week although, in reality, total farm work performed and wages paid could have decreased.

Initial survey data released by EDD, which showed an increase in San Joaquin Valley agricultural employment of 3,000 jobs between 2008 and 2009 during the growing season, were subsequently revised to show losses of 9,800 jobs during this period. Even with severe drought and an increase in fallowed acres, the initial EDD surveys were detecting job growth. This anomaly generated significant controversy, as partisan groups suggested that model-based estimates of job losses were false. It was not until September 2009 that the EDD released revised data showing 5,500 jobs lost in the San Joaquin Valley.

Figure 1. Summary of SWAP/IMPLAN Job Loss Forecasts and EDD Surveys by Forecast Date



Comparing EDD and SWAP Results and a Retrospective Assessment

SWAP is a method for forecasting drought effects on agriculture based on water supplies, whereas EDD surveys provide a useful retrospective benchmark. While the payroll data provide a valuable check, they come too late to influence current water policy which requires real-time forecasting of job and income impacts.

Figure 1 summarizes the difference in SWAP forecasts, predicted water cuts, and EDD surveys tabulated by the date when each of the four forecasts was made. EDD initially estimated job growth during the drought. The final estimate was not available until months after the growing season and long after important policy decisions had to be made. In contrast, SWAP and IMPLAN forecasts of job losses were revised down as additional SWP and CVP water was available and additional groundwater pumping took place.

The reason the model forecasts differ is because the available water supply changed during the time intervals between forecasts. An important follow-up question is how well the SWAP model, or agricultural production modeling in general, does when accurate water-supply data are used in the model.

We reviewed crop acreage data, employment surveys, census data, water-transfer data, and satellite images available in September 2010 to retrospectively determine the actual effect of the 2009 drought. We found that the SWAP and IMPLAN models produced accurate measures of job

Table 1. Summary of Forecasts, Retrospective, and Realized Effects of 2009 Drought on San Joaquin Valley Agriculture

Date of Forecast	Combined % Drought	Revenue Loss	Acres Fallowed	Jobs Lost
January 2009	29%	$1,400m	675,000	40,000
May 2009	21%	$710m	450,000	21,000
September 2009	21%	$710m	450,000	21,000
September 2010 Retrospective	11%	$370m	270,000	7,500
Actual	–	$340m	285,000	9,800

impacts when driven by accurate water-supply data. More specifically, when known water transfers and increased east-side local water supplies were included, the SWAP model forecasts of acres and job losses were consistent with the best available data. Table 1 compares the results of the three forecasts and the retrospective analysis, with the actual outcomes.

In order to use EDD employment data to determine past agricultural job losses due to drought, it is necessary to perform econometric analysis. This allows the researcher to control for outside (confounding) factors and determine how many of the total jobs lost can be attributed to drought.

In a recent edition of *ARE Update*, Sunding, Foreman, and Auffhammer report the results of such an analysis. They find that the 2009 drought, compared to a base year of 2005, led to 5,000 direct agricultural jobs lost. When jobs lost in industries related to agriculture are added in, the econometric estimates are consistent with estimates from the SWAP and IMPLAN analyses.

Conclusion

When water supplies are cut due to drought or environmental considerations, policymakers and interest groups want timely forecasts of the impacts on regional employment and income. Such forecasts can be provided through analysis of agricultural production models like SWAP. The accuracy of such forecasts depends largely on the accuracy of water-supply forecasts that are input into these models.

Both the water-supply-based modeling and retrospective EDD employment surveys were in error when examining the impact of the 2008–09 drought. However, in future forecasts using the agricultural production models, it will be possible to improve accuracy by focusing more attention on the surface and groundwater supply estimates, and the prevalence of water trading. However, it is hard to see how the survey sampling approach used by EDD can be improved without substantial additions to their sampling budget.

In the retrospective analysis, we found that significant water transfers took place and local surface water supplies were higher than anticipated. Consequently, the early forecasts were based on data that indicated a drought worse than actually realized.

The key lesson from forecasting the 2009 drought is that agricultural production models require accurate estimates of water availability over the coming growing season. However, the severity of a drought changes over time and the true extent of effects are not known until months later. Even with this limitation, when accurate water estimates are input into production models the result is an accurate analysis of real-time effects. In other words, it's the water.

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For additional information, the authors recommend:

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Biomass Ethanol Production Faces Challenges

Jadwiga Ziolkowska and Leo Simon

While ethanol has been recognized as an alternative to oil, the most viable source material for it remains a controversial topic. U.S. ethanol is produced primarily from a grain, corn, which has a number of disadvantages. Cellulosic ethanol has been promoted as a replacement. We review some of the strengths and weaknesses of cellulosic biomass ethanol, and discuss its potential for becoming part of the long-run solution for supplying energy to the United States.

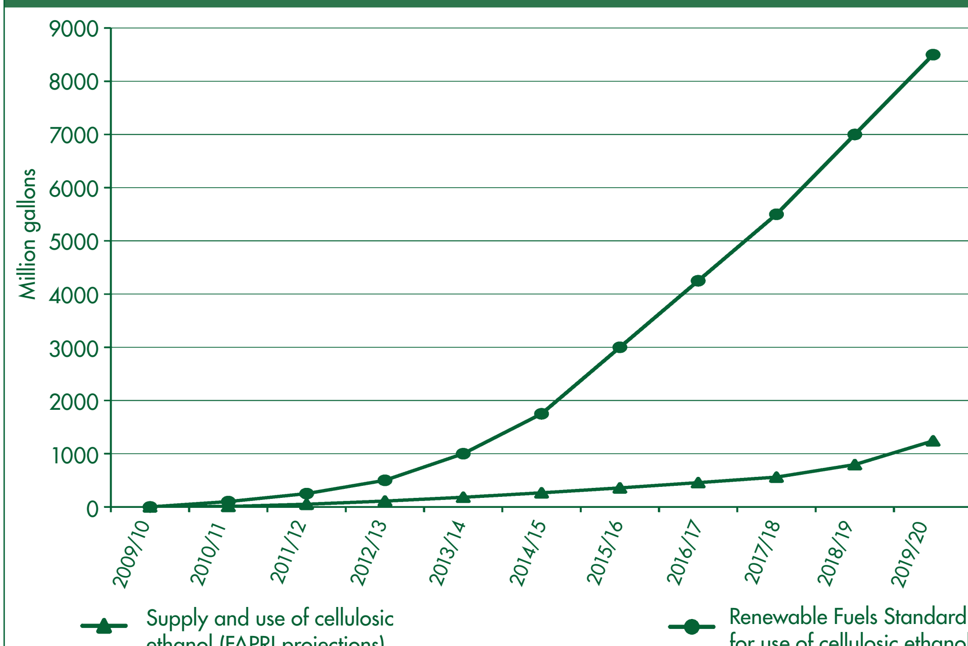
Cellulosic biomass ethanol (also called biomass ethanol) is derived from lignocellulosic or hemicellulosic matter and can be produced from various feed stocks, including agricultural waste such as rice straw, forest waste such as material created by logging, and energy crops grown specifically to produce biofuels, such as willows and other fast-growing trees and shrubs, switchgrass, and miscanthus. In general, the concept of producing a "green fuel," by transforming waste into byproducts, is attractive to many policymakers and environmentalists, and supported by some scientists. Support also exists for producing green energy using targeted crops that require fewer inputs than corn, although there is also concern that these crops compete with food crops for acreage.

In spite of the support for this energy source, there is currently no commercial-scale production of cellulosic biomass ethanol. A number of pilot projects that generate small amounts of ethanol are underway, and the first commercial-scale plant is scheduled to open in 2012. The expansion of biomass ethanol production has been much slower than projected. Policymakers' targets for levels of biomass ethanol production have not been met, leading to serious questions regarding whether or not biomass ethanol can play an important role in supplying energy to the United States.

Renewable Fuels Standards, set by the federal government in 2007 as part of the Energy Independence and Security Act, set a long-term goal of 21 billion gallons of ethanol to be produced by biomass and other non-corn starch feedstocks in 2022. Biomass ethanol production was only eight million gallons in 2010, far below the targeted 100 million gallons. Figure 1 reports specific projections by the Food and Agriculture Policy Research Institute (FAPRI) that predict this development path will continue. Given the large gap between the original targets and actual production, the Environmental Protection Agency revised its targets significantly downward, with a new 2022 target of 16 billion gallons.

One explanation for the slowness of this process is that subsidies for ethanol production have encouraged the expansion of corn-based production and discouraged innovation regarding alternative energy sources. A related explanation is that the benefits of biomass ethanol, relative to corn ethanol produced from the starch included in the grain, are not captured by ethanol producers in the absence of subsidies or by a higher buyer willingness-to-pay for ethanol with superior environmental benefits. Another is that the technology for producing biomass ethanol has faced many challenges in becoming commercially feasible. A fourth explanation

Figure 1. U.S. Cellulosic Ethanol Production and Consumption vs. Renewable Fuels Standards in 2009–2019



Source: FAPRI (2010)

Biomass ethanol production from crops such as miscanthus grass, pictured above, confront technological and economic challenges.

is that the appearance of completely new energy production technologies, such as petroleum-like hydroprocessing and direct solar-to-fuel processes, and their potential for commercial and political viability has discouraged investment in biomass technologies.

Comparison of Biomass Ethanol and Corn-based Ethanol

From the ethanol producer's perspective, there are a number of components of ethanol production costs. Feedstocks for biomass ethanol are cheaper than corn on a per-unit basis. Indeed, some of them currently have no market value. More units of biomass are required to produce a gallon of ethanol compared to corn, however, so that the feedstock cost for corn ethanol and biomass ethanol are quite similar per gallon of ethanol. The cost of converting biomass to sugar for use in ethanol is higher because the complex carbohydrate nature of biomass requires a more expensive two-stage conversion process. Overall, it is cheaper to produce ethanol from corn starch. Of course, this cost advantage varies with the price of the feedstocks. Figure 2 presents a 2010 estimate of total production costs and individual production cost components for corn ethanol and cellulosic ethanol.

The role of feedstock providers varies by the type of feedstock. For sources that are otherwise considered waste, whether or not it is supplied for ethanol production will depend on whether the net revenue from selling it is greater than the cost of disposing of it if it is not sold. Costs of marketing include transportation, and may include collection and storage.

The tradeoff is very different for potential producers of energy crops. In general, the tradeoff involves the benefits, costs, and perhaps the relative risks of producing an energy crop and growers' most profitable alternative crop. We focus here on the choice between producing an energy crop and producing corn. This choice involves a number of considerations. Biomass has two production advantages relative to corn. Corn for grain requires a substantial amount of nitrogen fertilizer per acre.

In comparison, the energy crop miscanthus requires virtually no nitrogen, and also generates sufficient biomass to produce much more ethanol per unit of production than corn grain. On the other hand, miscanthus requires more water than corn. This can reduce its relative attractiveness to growers who are dependent on irrigation to meet crops' water needs. Thus, the relative attractiveness of these crops for feedstock producers will depend in part on the costs of these inputs and the precise relationships between their input requirements under specific production conditions.

Another consideration for growers choosing whether to produce an energy crop concerns their "outside options" for marketing. There may be only one biomass ethanol producer within a grower's region. If this producer halts or reduces production, a grower may be left with an unmarketable specialized energy crop, whereas a grower who produces corn has many marketing options.

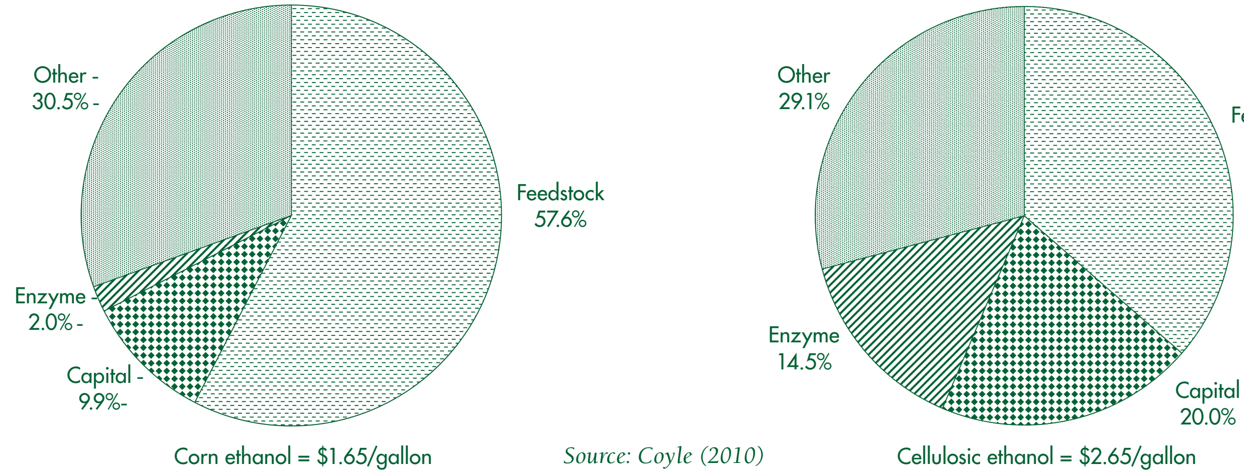
The social desirability of corn ethanol versus biomass ethanol involves many considerations. At the feedstock production level, one consideration is that biomass (miscanthus, specifically) can produce more ethanol on a per-acre basis than corn. Thus, less land is required to produce a given amount of ethanol from biomass, all else equal.

Similarly, as noted, less nitrogen fertilizer is required per acre and per unit of ethanol produced. Nitrogen fertilizer use can result in nitrate contamination of groundwater and surface water. In addition, fertilizer requires energy to produce. Even taking into account the ethanol that can be produced from the corn plant material that is a byproduct of grain production does not eliminate the advantage of miscanthus.

A significant concern regarding corn ethanol production is that it competes with other uses of corn, raising its price for uses in food directly and indirectly through raising the cost of livestock production. To the extent that energy crops compete with food crops for land, they may also raise food prices, so that there is no clear advantage for either feedstock in this regard. To the extent that energy crops can be grown on marginal land not suitable for food crop production, their effect on food prices will be lessened, increasing their social benefits relative to corn ethanol production. Using marginal lands for energy crop production may have other social costs, however, such as replacing natural habitats.

An important environmental advantage of biomass ethanol from energy crops compared to corn ethanol is that it reduces emissions of greenhouse gases over the lifecycle of the fuel, from feedstock production

Figure 2. Corn and Cellulosic Ethanol Production Costs



Source: Coyle (2010)

to final use. The advantage varies by feedstock. Switchgrass is considered a relatively attractive option.

Summarizing, the attractiveness of biomass ethanol as an alternative to corn ethanol depends on one's perspective. Feedstock growers face a complicated tradeoff; and region- and individual-specific factors will play an important role in determining which type of feedstock is more profitable to produce. From the perspective of an ethanol producer entering the market, corn ethanol is a more attractive choice economically. From society's perspective, benefits of biomass ethanol that are not captured by producers may outweigh these private benefits. However, some government policies may encourage the production of corn starch ethanol rather than biomass ethanol.

Energy Policy and Biomass Ethanol Production

Government policy has sought to encourage ethanol production in a number of ways, including providing funds for research, grants and loans to producers, income tax credits, and subsidies. Subsidies do not encourage the use of biomass for ethanol production because they do not differentiate between sources. Volume-based subsidies tend to encourage the production of ethanol from corn, which has a higher yield and lower production cost.

The government has also sought to influence ethanol production through regulatory mandates, such as blending requirements for automobile fuel.

As part of the implementation of the Energy Independence and Security Act of 2007, the EPA introduced another mandate: biofuels must reduce greenhouse gas emissions over their "life cycle," including production. Specific mandates vary by source: the mandated reduction for biomass ethanol is much greater than that for corn starch-based ethanol. This mandate adds to the challenge of developing economically viable commercial-scale production of biomass ethanol.

Technology Development Challenges

From a production standpoint, biomass ethanol production is more effective when a range of biomass sources are used simultaneously. Electing not to use a mix of fuels reduces the economic viability of production. However, capturing this benefit complicates the choice of location for a commercial-scale plant and its procurement strategy.

Some supporters of corn-based ethanol argue that there are complementarities to be captured by co-locating a plant that produces ethanol from corn grain and a plant that produces ethanol from biomass. Co-location allows corn plant biomass that is a byproduct of corn grain production to be used for ethanol production. This strategy can complicate procuring a range of biofuels while capturing the environmental benefits; planting energy crops in corn production areas increases the likelihood that these crops will compete directly with food crops for acreage.

Potential Alternatives

Researchers have moved beyond improving techniques for producing cellulosic ethanol, and are investigating new technologies. These potential alternatives are primarily based on the possibility of genetically modifying crops to consume more carbon than is released when they are used as fuel. Effectively, the process is to convert carbon dioxide into carbon and oxygen. Thus, these alternatives are considered not only renewable, but "carbon-negative."

From a policymaker's perspective, encouraging further research into these technologies may have a higher expected return to society than funding additional research regarding the improvement of technologies for producing biomass ethanol.

Future Prospects for Biomass Ethanol

Technological and economic challenges confront biomass, or cellulosic, ethanol production. To date, its production has increased much more slowly than projected. Biomass ethanol was originally seen as a more socially desirable alternative to corn ethanol. While biomass ethanol has several advantages relative to corn ethanol, it does not dominate corn ethanol in all respects. It is unclear whether investing additional resources into promoting biomass ethanol production through various policy initiatives is socially desirable, or whether it should be left entirely to private actors. To the extent that the government involves itself in developing alternatives to oil as energy sources, it may be more desirable to invest in newer technologies.

Nonetheless, biomass ethanol may have a role in the future of U.S. energy, even if it is smaller than was once imagined. One possibility could be specialized niches that generate specific advantages for a production region. In California, for example, generating ethanol from rice straw could benefit rice producers. Historically, producers burned rice straw as part of their disease and pest-management strategies. Environmental considerations have sharply curtailed this practice over the past twenty years, and no loosening of this restriction is anticipated.

While to some extent rice producers have been able to compensate for the loss of burning as an annual tool, the compensation is incomplete. For example, tadpole shrimp have increased in importance as a pest of rice grown in the Sacramento Valley. Copper sulfate is a commonly used treatment for tadpole shrimp and algae, another rice pest. There are concerns that large amounts of rice straw left in a field reduces the effectiveness of copper sulphate because it binds to the straw rather than affecting the target pest.

Developing commercial production of biomass ethanol from rice straw in the Sacramento Valley would convert rice straw from waste into a marketable byproduct for growers, and potentially aid in pest management. However, the various market considerations discussed above can limit the commercial viability of this strategy.

Biomass ethanol's potential to be a substantial contributor to U.S. energy needs is in doubt. At this time, corn ethanol dominates the U.S. market. Newer alternatives may leapfrog biomass ethanol in attractiveness for commercial production.

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Health, Diet, Nutritional Information, and Consumer Choice

Amir Heiman, Oded Lowengart, David Zilberman, and Maayan Klachman Amir

This paper presents the results of experiments that aim to understand the effect of calorie information on consumer choices. Since individuals tend to overestimate the calorie differential between foods, providing calorie information by itself leads to switching from lower calorie foods, like chicken to tastier but higher calorie foods like beef. Providing information about the amount of exercise required to eliminate the impact of additional calories shifts consumption from meats to salads.

Policy makers, physicians, and concerned family members are interested in designing strategies that will encourage people to make healthier nutritional choices.

Consumer assessment of food choices (e.g., whether to eat chicken, beef, or salad) is comprised of perception and bias. Some consumers are affected by cognitive dissonance, i.e., they assume that they are exempt from a bad outcome since they control their choice of food.

The literature shows that consumers overestimate the amount of calories that they burn vs. calories that they need (my body is functioning well, so I eat what I need). Smokers are less likely to be concerned about the risk of smoking than nonsmokers.

Another bias is with respect to the nutritional content of food that may be associated with stigmas. Consumers may overestimate the calorie content of beef while underestimating that of chicken.

This paper presents the results of experiments that aim to understand the effect of calorie information on consumer choices. Obesity is often considered to be the most threatening modern epidemic. Scientists distinguish between two categories—overweight and obese. Overweight is defined as having a body mass index (BMI) that is between 25–30% higher than normal. Individuals with still higher BMIs are considered obese. Among U.S. residents, 69% are overweight—33% of males and 35% of females are obese. Being overweight, in general, and obese, in particular, have been associated with an increased risk of cardiovascular (heart) diseases, type 2 diabetes, and various types of cancers. The cost of healthcare for an obese individual is about 37% higher than for a healthy-weight individual. The total additional cost related to obesity is $732 per capita in annual medical bills. In the European Union (EU), more than 50% of the adult population is overweight or obese. Germany leads the EU with overweight individuals, and the United Kingdom and Greece lead in the proportion of obese individuals in the population. In the EU in 2006, direct obesity-related health-care costs were estimated at € 59 billion.

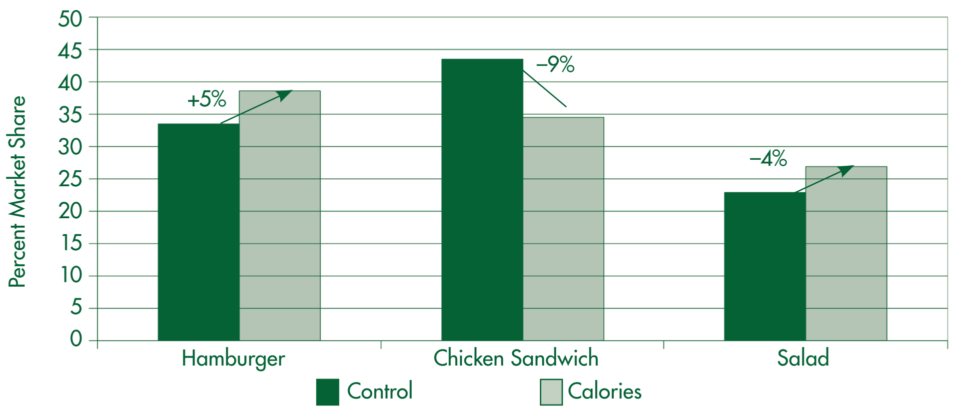
Policy makers have taken various measures to slow, or reverse, the pace of weight gain. These include the mandatory labeling of the calorie content of restaurant-menu items in chains that have more than 20 outlets. Previous studies suggest that calorie posting has an insignificant effect on calorie consumption as most consumers resist changes in eating behavior. While the majority of consumers seem to ignore calorie information, a small fraction of consumers (7–15%) change their food choices toward a lower calorie diet. However, empirical evidence shows that there is a segment (nearly as large as the segment that reduced calorie consumption) that actually increases its consumption of higher calorie food after posting of calorie information.

The low effectiveness of the provision of calorie information as a major measure to fight obesity increases the likelihood of alternative policy measures, in particular, taxing, banning, and restricting the production, advertisement, and sale of high-calorie products. Behavioral economics takes into account consumer cognitive limitations (e.g., it is costly and tiring to process information precisely) that lead to shortcuts in behavior and simplified assessments. This theory suggests new experiments that may lead to a better understanding of consumer choice and result in better policies, including more effective provision of information.

Errors in Calorie Estimation and Implications

Behavioral economics suggests that sometimes consumer perceptions are different than reality. This is true when it comes to calorie intake. Some studies suggest that consumers tend to underestimate their actual calorie intake. Other studies found that consumers tend to overestimate the

Figure 1. Choices With and Without Calorie Information



calorie content of the less-healthy food products while underestimating the calories of the healthier products. These findings served as a foundation for policy makers who advocated the legislation to make the calorie postings of restaurant chains mandatory.

We challenge the logic of this mandatory calorie-policy legislation. When consumers underestimate the calorie content of the hamburger and have an accurate perception of the calories of the healthier alternative, then posting calorie values makes sense, as some consumers will shift to the lower calorie option while others will stick with their first choice of the hamburger. However, there may be a boomerang effect, and consumers may shift from a chicken sandwich to a hamburger if the calorie content of the healthier option has been underestimated in their minds.

Studies suggest that the reason for the boomerang effect is that consumers relate higher calorie content with better taste. If consumers realize that they overestimated the calorie savings and health gains associated with consuming healthier food, they may update their choice because the new information that reveals the difference in caloric content does not justify the sacrifice of taste (pleasure).

These effects may cause calorie-posting policies to be inefficient, but not because consumers ignore calorie information but, rather, because they act rationally given updated information.

The Effect of Calorie Information on Choice of Fast-food Products

To analyze the effect of information updates on judgments and choices, we used a research design that distinguishes between a control group and two treatment groups—the calorie group and the workout group. The control group viewed a regular menu of a fast-food chain containing a picture of the dish, description (e.g., salad with vinaigrette dressing), and price. The calorie group viewed the same menu plus calorie information. The workout group received the calorie information plus information on the amount of time of a workout activity (e.g., walking) that is needed to burn the calories consumed.

The respondents received a menu that included the three research products: a hamburger, a chicken sandwich, and a green salad, plus French fries and a soft drink as fillers.

Similar to many consumer behavior and psychological studies, we did not make the extra investment to obtain a sample that is representative of the population but, instead, studied the effects of different information manipulations within a population that was easily approachable.

Our main concern was to guarantee randomness of allocation of the population among the control group and treatment groups. The choice of location where subjects were recruited had to satisfy only one condition—that fast-food outlets were nearby. We screened out consumers who had not eaten at hamburger chains during the past year.

The three experimental surveys were conducted at the university town of Rehovot, Israel. The majority of subjects were students, while others were employees and visitors, including parents. We also interviewed students at a nearby high school (about 20% of the sample) and two workplaces that were near McDonald's and other fast-food outlets.

Overall, we interviewed 511 respondents who were randomly assigned to one of the three experimental groups. Our sample contained 186 males and 325 females. The higher proportion of females to males (63.5 percent) reflected the proportion of female students in the Faculty of Agriculture, Food, and Environment, where the majority of interviews were held.

Regarding responders' ages, 19.3% were below 20 years of age, 22.7% were between 20 and 30 years, 16.6% were between 31 and 40 years, and 41.4% were over 40 years of age. With respect to income, 36.3% had incomes that fell below the national average, 15.7% had average incomes, and 48% had above-average incomes.

Members of the control group were asked about their estimation of the calorie content of the three research products considered. The results showed that they overestimated the calorie content of the hamburger and the chicken sandwich, but their estimation of the calories of the salad was not biased. This confirms the findings in the literature that consumers overestimate the calories in calorie-rich foods. Furthermore, the magnitude of overestimation was higher for the hamburger than for the chicken sandwich. Given this pattern of overestimation, it is likely that consumers will shift their demand from the chicken sandwich to the salad if the benefit of weight control is stronger than pleasure and vise versa. They will shift to the hamburger if they assign a greater importance to pleasure than to the goal of weight control.

The actual calorie difference between the hamburger and the chicken sandwich is quite small--368 and 318, respectively. The difference of only 50 calories may result in a boomerang effect. Figure 1 presents the choices of the three products with and without calorie information and confirms that the boomerang effect, indeed, occurred. The results suggest that calorie information lowered the demand for the chicken sandwich while the demand for the hamburger and the salad increased

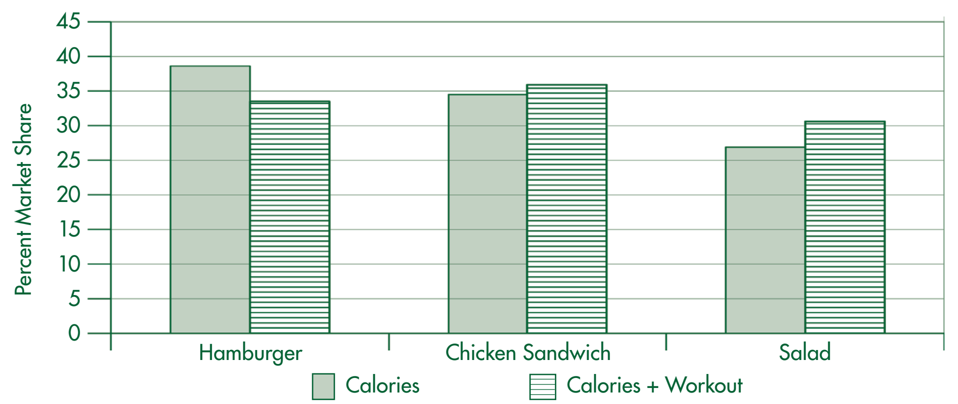
However consumers' response to calorie information is expected to be sensitive to additional information that allows better interpretation of the basic facts. When calorie information was coupled with workout information that specified the time needed to burn calories consumed, it provided a price tag on the extra calories of the hamburger in terms of calorie-reduction efforts.

Figure 2 compares the market shares of the three fast-food products between the two information manipulations—calories only and calories plus workout efforts. The additional information led to a decline in the demand for the chicken sandwich and a transition mostly to the salad but also to the hamburger. The calories and workout information did not change the consumption of the hamburger compared to the control group but led to a major shift from the chicken sandwich to the salad. The additional information on workout time, which visualized the cost of calorie consumption, corrected the undesired results (from the standpoint of the designer).

Gender Effect

The literature suggests that there are differences in preference between genders, resulting from differences in metabolism and energy demand, as

Figure 2. Market Share With Calorie and Workout Information vs. Calorie only



well as attitude toward risk, health, and appearance. Therefore, men tend to have a higher preference for the hamburger (more energy) and women, the salad (less fat). Indeed, in the control group, 60% of men preferred hamburgers; 35%, chicken; and 5%, salad. Few women selected the hamburger, and the rest were divided between the chicken sandwich and the salad. When only the calorie information was available, both men and women shifted from the chicken sandwich to the hamburger. With additional information about workout time, men shifted to the chicken sandwich and women shifted to the salad.

Discussion

Policy makers, physicians, and concerned family members are interested in designing strategies that will encourage people to make healthier nutritional choices. For example, with concerns about obesity, it may be desirable to induce the transition to healthier, leaner foods.

A basic assumption is that the provision of calorie information will lead to improved choices. But behavioral economics suggests that consumers' perceptions are sometimes inaccurate. In our case, they tended to overestimate the extra calories in the hamburger relative to chicken. Thus, when provided with only the calorie content, there was a boomerang effect—a shift away from the leaner option. Only when additional information was provided about the costs in terms of choice, additional required workout time to burn the calories in the case of our experiment, did individuals correct themselves and increase their selection of leaner food. This suggests that providing only partial information may lead to an undesirable outcome. To make a wise choice, consumers need both the basic facts as well as the implications.

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