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# UPDATE

## Agricultural and Resource Economics

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### What Price Should be Paid to Keep U.S. Dependence on Foreign Oil in Check?

by  
*Y. Hossein Farzin*

*The long-run U.S. oil supply, and hence oil security, depends significantly on additions to proven reserves—a process which is importantly influenced by the long-run, expected oil prices, in addition to geological or technological factors. It is shown that if U.S. oil import dependence is to be kept in check, steady annual oil price increases of 1.6-4.5% are essential.*

Once again, U.S. energy security has become the center of intense debate both in policymaking and public opinion circles. The debate has prompted concerns about U.S. future domestic oil and gas supplies and its dependence on imported oil. The bases for these concerns cannot be properly addressed without first answering the more specific question: *In the face of steady economic growth and growing oil consumption, what price should the United States pay for keeping its dependence on foreign oil in check?*

To answer this question, in turn, requires a good understanding of the relationship between oil price changes and additions to proven reserves. Yet, this relationship has not been adequately explored either by previous scholarly studies or by energy supply forecasting agencies. For example, the U.S. Department of Energy which uses oil reserves estimation techniques that rely mainly on reservoirs' production history and geological and engineering principles, and fails to incorporate economic factors.

In an *economic* (as opposed to *geological*) concept of reserves, the economic size of reserves of a depletable resource,

instead of being assumed fixed and known, depends on expectations of future price, reserves discovery and development costs, and the state of technology.

I have modeled additions to proven reserves as a conventional production process in which drilled wells act as a primary input to convert some of the stock of oil-in-place into the economic category of proven reserves. The model attempts to incorporate the three salient economic, geological and technological effects that influence the process of additions to proven reserves. These are, respectively, the effect of oil price on drilling activity level, the effect of reserves depletion on discovery and development costs, and the effect of technological progress on those costs.

#### Factors Influencing Reserves Additions

Additions to reserves are an outcome of combined geological, technological and, above all, economic factors which are hard to model. The growth of oil reserves stems from two broad sources: the discovery of new fields and additions to reserves in known

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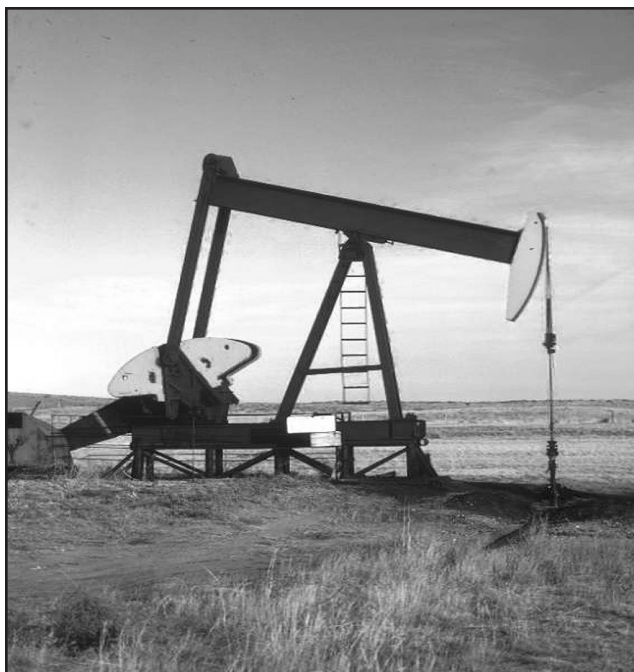
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*Additions to proven reserves is a price sensitive production process in which the drilling of wells leads to conversion of some oil-in-place to the economic category of proven reserves.*

*Photo by ArtToday.com*

fields. The first source, which is the result of drilling exploratory wells, is characterized by a high degree of uncertainty and provide a rather insignificant contribution to the U.S. total reserves additions. (The U.S. average success rate in exploratory drilling was about 15 percent by 1970, rising to about 25 percent by early 1990s, and to nearly 40 percent by 1998 due to a number of recent technological advances in oil exploration.) Over the period 1949-1995, the average annual addition to proven reserves from new field discoveries was only 250 million barrels, or about 11 percent of the average total reserves additions. This study has not been concerned with reserves additions due to new field discoveries and instead concentrates on additions resulting from extensions of reserves in known fields.

Extensions are recoverable reserves that result from changes in the productive limits of known reservoirs. After the discovery of a reservoir, additional wells are normally drilled to outline the productive limits of the reservoir. In the process, more reserves may be found than initially indicated at the time of discovery. Reserve additions from this source are likely to decline rapidly as cumulative additions due to extensions increase, since a significant portion of extensions usually occurs within the first few years after the reservoir discovery. Extensions can result

from either exploratory or development drilling. The degree of risks and returns associated with each of these modes of drilling differs substantially.

Exploratory drilling usually involves few wells that are drilled beyond the geographical limits of recent discoveries in order to find new reservoirs or open up neglected, deeper strata in old reservoirs. With exploratory drilling, the probability of discovery is relatively small but the size of discovery can be relatively large since it would be the first drilling effort in the region.

On the other hand, development (or "infill") drilling involves many wells that are usually drilled in years subsequent to discovery of a reservoir, in order to either reach previously untapped portions of the reservoir or to access spaces wherein the natural force of the reservoir is insufficient to mobilize the oil-in-place. In this mode of drilling, the probability of adding to existing reserves is relatively large but the expected size of additional reserves is likely to be small. Furthermore, as cumulative development drilling and, hence, cumulative addition to reserves increases, reserves additions resulting from new development wells are likely to decline simply because there will be less recoverable resources in place.

In deciding how to allocate their drilling activities between exploratory and development drilling, producers make a trade-off between expected return and expected risk, depending on their attitudes toward risk. Everything else being equal, the more that producers are risk averse, the greater their preference for development drilling. Given the producers' attitude toward risk, both the level and mode of drilling will depend on a number of economic factors. Among the most important are likely to be expected oil prices and drilling costs. Expectation of a lower future price is not only likely to reduce the total number of wells to be drilled, but also to give producers an incentive to shift from riskier exploratory drilling to relatively less risky development drilling.

Over the period from 1949 to 1995, the average additions to proven reserves from all sources was 2.35 billion barrels a year, which amounted to 8.2 percent of proven reserves on average. In the United States, historically, most of the additions to oil reserves (nearly 90 percent on average over the 1949-1995 period) can directly or indirectly be attributed to development drilling which has resulted in increased recovery rates from existing fields. (This average consists of 28.6 percent due to extensions, 6.5

percent due to new discoveries in existing fields, and 54 percent due to revisions and/or adjustments.)

Several important features should be noted regarding drilling costs. First, both total and incremental costs of drilling wells are likely to vary from one production district to another depending on geological characteristics of each district. Second, average cost per well in a producing district may rise with the total number of wells drilled in that district in a given period of time due to limited supplies of skilled labor and specialized capital equipment in the short run. This effect may be offset to some extent by economies of scale. Third, development drilling costs have the additional feature of rising with the cumulative amount of reserves withdrawn, reflecting a shrinking size of the remaining oil-in-place as a base for reserve additions. Fourth, improvements in drilling technology over time can exert a favorable effect in reducing drilling costs.

With this background, I have studied the decision-making of a typical firm which forms its expectations of future prices and determines its desired level of development drilling, and hence additions to proven reserves, so as to maximize the expected profits from its drilling activity. Based on that model, I have been able to derive a relationship between additions to proven reserves from existing fields and the main determining economic and technological factors. I have then estimated the relationship for the U.S. over the period 1951-1995.

### Main Results

The statistical estimations suggest several interesting points:

(1) In forming their expectations of future oil prices, producers do not rely merely on the current price but attach rather significant weights to very recent past prices too. This may in part reflect oil producers' perception of oil price volatility in the short-run, which stems, for example, from political uncertainties in the oil-exporting nations or uncertainties in domestic regulatory policies.

(2) More interestingly, I obtain an estimate of the short-run price elasticity of reserves addition of around 0.11 and a long-run price elasticity of around

0.16. Accordingly, the quantitative impact of oil price on reserve addition, although rather small, is by no means insignificant. For example, a 10 percent (or nearly \$1.20 per barrel) increase in the average real oil price (which was \$12.20 per barrel over the sample period) would immediately bring about nearly one percent (or about 12 million barrels a year) increase in average addition to proven reserves. Furthermore, the impact of a price increase on reserve addition is fully born out in a very short period of time.

These results make it clear that oil price increases are essential for the growth of proven reserves. This

point is better appreciated once we note that, based on the estimated reserve addition relationship, even if one assumes a steady rate of technological progress and ignores the negative depletion effect, then with the oil price remaining unchanged at its 1995 level, the cumula-

tive additions to reserves (due purely to technological progress) will be only about 8 percent over 10 years. On the other hand, ignoring the technological progress but allowing for the negative depletion effect, a one percent steady annual increase in oil price brings about a 44 percent cumulative reserve additions over the same 10-year period. This raises a question the answer to which can provide valuable insight about the role of oil prices in shaping the dynamics of U.S. dependence on imported oil: *What is the annual constant real rate of oil price increase that is needed to keep the share of oil imports in total oil consumption, the reserve-production ratio, and hence the reserve-consumption ratio constant over time?*

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***“This study makes it clear that increases in oil prices of 1.6-4.5% per year are essential...to keep U.S. foreign oil dependence in check...”***

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*Under a business-as-usual scenario, the model predicts that the share of U.S. oil imports in consumption will rise from their 1995 level of 58% to over 72% by 2010.*

*Photo by ArtToday.com*

**Table 1: Rate of Annual Price Increase Required to Keep U.S. Oil Import Dependence Intact**

	GDP Growth	
	2%	3%
Income elasticity=1.0		
Price elasticity=0.5	3.62	4.53*
Price elasticity=0.75	2.19	3.30
Income elasticity=0.75		
Price elasticity=0.5	2.26	3.40
Price elasticity=0.75	1.64**	2.47
<p><i>Income elasticity is the percent increase in oil demand due to a one percent increase in consumer income. Price elasticity is the percent decrease in oil demand due to a one percent increase in the oil price.</i></p> <p>* This value reflects the high-case scenario with oil demand characterized by high income elasticity of 1, a high GDP growth rate of 3%, and a low price elasticity of 0.5.</p> <p>** This value reflects the low-case scenario with a GDP growth rate of 2% a year and a low oil demand.</p>		

The long-run price elasticity of reserve addition (estimated to be 0.16) is a key element in answering this question. More specifically, I have derived a simple formula that shows that the required rate varies directly with the growth rate and the income elasticity of oil demand and, inversely, with the price elasticities of reserve addition and oil demand. One may think of this rate as a premium that needs to be paid in order to prevent U.S. dependence on foreign oil from rising in the future in the face of steady rates of economic growth and, hence, higher oil consumption. Table 1 presents the magnitude of the required rate of oil price increase calculated for different stipulated values of long-run GDP growth rate ( $g=2\%$ ,  $g=3\%$ ), oil demand price elasticity ( $b=0.50$ ,  $b=0.75$ ) and income elasticity ( $a=0.75$ ,  $a=1.0$ ). The required price increase will be as low as 1.6 percent a year in the low-case scenario specified by an expected steady economic growth rate of two percent a year and an oil demand characterized by a high price elasticity of 0.75 and a low income elasticity of 0.75. In the opposite (high-case) scenario, characterized by a high rate of economic growth (three percent a year) and a high oil demand (price elasticity of 0.5 and income elasticity of 1.0), the needed rate of oil price increase rises to about 4.5 percent a year.

Even under this latter scenario, the required rate of price increase seems modest, or at least not unduly large; it implies a doubling of the real oil price in 15 years. On the other hand, suppose the oil price is kept constant at its 1995 level and that we rely exclusively on the technological progress rate of 0.57 percent a year to develop new oil reserves. Then, even if the negative reserve depletion effect is ignored, with a steady three percent annual growth rate in oil consumption, the share of oil imports in consumption is estimated to rise by nearly 1.5 percent a year. At this rate of increase, imports would rise from their 1995 level of 58 percent to over 72 percent by 2010. Of course, allowing for the negative depletion effect, the implied degree of foreign oil dependence will most likely be much higher than that.

### Conclusion

This study shows that increases in oil prices of 1.6 - 4.5 percent a year are essential for sufficient growth of proven reserves to keep U.S. foreign oil dependence in check in the face of steady growth of economic activity and, hence, oil consumption. Bearing in mind that oil prices are not determined domestically, these findings accentuate the importance of alternative policies to ensure sufficient future domestic oil supply. Such policies may include less stringent leasing regulations for oil prospecting firms or fiscal measures (tax credits/subsidies) to boost drilling activity and to encourage research and development investments aimed at technological innovation and adoption in oil development and exploration. Rationale for these policies is reinforced if private firms undervalue the increased national oil security resulting from increased proven reserves.

For more detail on the article, the author suggests: "The Impact of Oil Price on Additions to U.S. Proven Reserves," Y.H. Farzin, *Resource and Energy Economics*, 23, 2001, pp. 271-291.

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# Privatization and Innovation in Agricultural Biotechnology

by

**Gregory Graff, Amir Heiman, Cherisa Yarkin and David Zilberman**

*Agricultural biotechnology as a science exists thanks to publicly funded research, but it exists as an industry thanks to privately funded product development. How compatible are these two?*

Over the last 150 years, agriculture has seen several waves of innovation based on scientific developments in machinery, chemistry and biology. Each wave has increased productivity, altered input use and modified industrial structure. The latest wave, agricultural biotechnology, has reshaping agriculture just as profoundly as the earlier ones. In particular, this wave has been marked by a massive privatization of agriculture's genetic inputs. Understanding this privatization is important in formulating government and university policies.

## Privatization and Technology Transfer

"Biotechnology" usually refers to the application of biological tools and techniques that identify genes, turn them on or off, and move them between organisms. Applications of biotechnology have been developed from a score of basic research breakthroughs, many of which occurred in universities and were then transferred to the private sector to be used in commercial research and development (R&D). Because of long product development lead times, uncertainties, and large downstream investments, private commitments to develop university-spawned technologies rest upon prospects for sufficient returns, something greatly enhanced by intellectual property protection. With this understanding, the Bayh-Dole Act, passed in 1980, gave universities the right to patent discoveries resulting from federally funded research. Most universities have established Offices of Technology Transfer (OTTs) to identify patentable inventions and license the rights to those inventions to private companies.

U.S. universities have seen an increase in the utilization of academic inventions by business and have received significant licensing royalties, amounting to over \$1.2 billion in 2000. Typically, much of the benefits captured by universities are created by a small number of big technology hits, such as the broad international protection and licensing of strawberry varieties, which have

generated over \$85 million for the University of California since 1982.

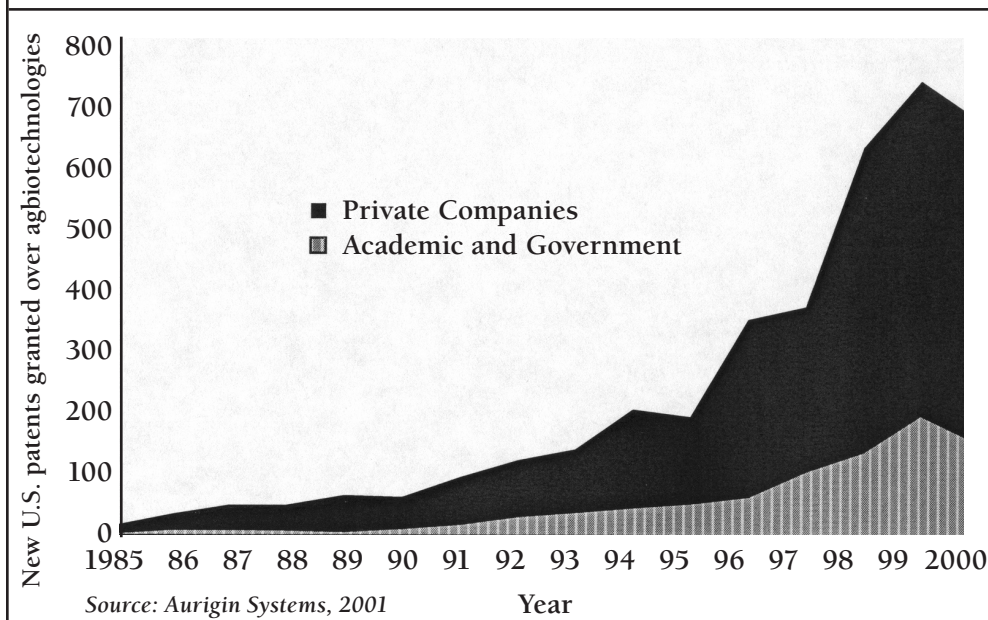
## Startups and Takeovers

While the Bayh-Dole Act addressed some of the legal impediments to the commercialization of inventions made by academic scientists, two factors continued to limit private interest in investing in promising academic inventions: the high uncertainty associated with the new technologies and the resistance of some corporate R&D departments to go outside for new ways of doing things. University technology transfer efforts have thus, in many instances, focused on starting up new firms, teaming up university scientists with promising inventions with interested venture capital investors. U.S. university technologies have helped spawn over 3,300 new companies in the last 20 years. Major biotechnology companies like Genentech (South San Francisco, CA) and Chiron (Emeryville, CA) and agricultural biotechnology companies such as Calgene (Davis, CA) and DNA Plant Technologies (Oakland, CA) all started with technologies that originated in university labs. Once a startup's technology is sufficiently developed and demonstrates commercial viability, major corporations may then invest, sometimes to the extent of acquiring that startup. Monsanto, for example, acquired Calgene, and Savia, a vegetable seed giant, acquired DNA Plant Technologies through its U.S. subsidiaries Seminis and Bionova.

## Gains from Privatization of Knowledge and Private Investment in R&D

Universities are still a major source of new biotechnology innovations in spite of the increased privatization of biotechnology (see Figure 1). Universities contribute to industry's productivity both by transferring technologies directly to existing companies and by spawning new companies that drive new competition with existing companies. Consumers benefit from the introduction of new

**Figure 1. Growth in the Number of U.S. Patents over the Biotechnology and Genetics of Crop Agriculture, 1985-2000**



products, higher quality and lower prices. Even when an industry is stagnant and not very innovative, universities can be a source of technological change and competitiveness. Investment by venture capitalists or multinational companies in university-spawned biotechnology startups depends fundamentally on expected profitability, but it is also important for risk management, strategic positioning and firm learning. In addition, the takeover of start-up companies at healthy prices provides an exit strategy that serves as an economic stimulus to encourage other inventors and venture-minded investors to shoulder the risk of starting up new biotechnology firms.

### The Long-term Effects of Proprietary Control over Knowledge

The patenting and licensing efforts of universities appear to have enhanced the utilization of academic discoveries in the short run, but constrained access to proprietary knowledge may slow down biotechnological innovation in the longer run. The ability of researchers in universities and international agricultural research centers to develop and introduce new technologies can be hampered by the legal intellectual property (IP) constraints on the use of proprietary knowledge, particularly tools that are key to research as well as to product development—tools such as the gene gun and

*Agrobacterium* genetic transformation or the genetic “on” switches called “promoters.” Academic and non-profit researchers are reportedly finding some research projects or plant variety rollouts held up or delayed until they can gain access to the rights. This sometimes means waiting until key patents expire. Furthermore, if they cannot gain access to the state-of-the-art technologies, academic researchers risk falling behind their commercial coun-

terparts. In the long run, this may reduce the rate of advance in basic science and, in turn, in commercial applications, in effect killing the goose that laid the golden egg.

### Biotechnology and Developing Countries

Private investment in agricultural biotechnology has emphasized major U.S. crops such as maize, soybeans, cotton, potatoes and tomatoes, as it seeks out large potential markets where expected returns are high and intellectual property protection is good. Significantly less research effort has been devoted to crops important in poorer regions of the developing world, even though agricultural biotechnology innovations—being embodied in the seed—are perhaps uniquely well suited to attack agronomic and environmental problems in economically and technologically less-developed areas. For these areas to benefit, it is necessary for the public sector to invest in the application of biotechnologies. This, however, requires access to those basic biotechnology tools that are largely controlled by private companies. Even when the companies are willing, transferring these tools entails high transaction costs for license negotiations, biosafety testing and product registration. Under the current situation, the productivity and income gap between farmers in developed and developing regions can be expected to increase, even though biotechnology

has significant potential to improve the well-being of poor and subsistence farmers.

### **Managing Intellectual Property**

Special arrangements for management of intellectual property and technology transfer could facilitate biotechnology-based agricultural development that addresses the needs of the poor in developing countries. One possible arrangement is an intellectual property clearinghouse for agricultural biotechnology that provides up-to-date patent information, helps execute licensing transactions and pools together key systems of patents to decrease transaction costs in the management of intellectual property permissions.

### **The Future of Agbiotechnology**

While the commercial developments of agbiotech thus far primarily benefit producers, crop genetic research is also enhancing nutritional value and other output quality traits to benefit processors, food retailers and final food consumers while also enabling “bioprocess” production of biomaterials and chemicals inside crop plants. Introduction of such quality-enhanced innovations are likely to cause an increase in downstream vertical integration for two basic reasons. First, the companies that develop the genetics may need to mediate farmer adoption, to assure them of adequate returns, especially when consumer acceptance is unclear or costs of production are high. Firms will therefore likely engage in contractual arrangements—such as those already prevalent in livestock and vegetable production—designed to reduce grower risk and facilitate adoption. The second reason for more vertical integration is that firms creating the genetics for quality-enhanced varieties may move to capture the value created by increased product differentiation downstream in processing and retail markets. This will mean greater product differentiation at the farm gate as well. Growers currently producing major commodities, subject to oversupply and low prices, are already interested in augmenting their revenues by growing niche products that use similar growing processes but require separate handling and identity preservation. In the wake of the recent incident over leaked corn that contained a hog vaccine molecule, politicians from Iowa objected loudly to a proposal by the Biotechnology Industry Organization for voluntary

guidelines to keep such pharmaceutically enhanced corn from being grown in the Corn Belt; Iowa farmers see this as potentially big new business.

Further in the future, change in the structure of the agricultural inputs industry also may arise in cooperation or integration between the new agbiotech companies and machinery suppliers, depending upon the degree of complementarity to emerge in the relationship between genetic inputs and precision agriculture. Precision farming offers possibilities to increase productivity through optimized planting and care of finely tailored genetics, which may generate an expanded market at the farm level for biotechnology products, especially in areas with high local variation in agroecological conditions.

### **Conclusion**

The introduction of biotechnology to agriculture has happened concurrently with the increased patenting and transfer of biological knowledge from the public to the private sector. Often the vehicle for this transfer has been the startup company, created to bear the risk of commercial development of the public sector invention. Establishing proprietary rights over knowledge enhances the incentives for commercial development, but it may constrain future innovations in both the public and private sectors. The two likely outcomes are market differentiation in IP rights using market institutions like the IP clearinghouse and the increased privatization and integration of agricultural value chains as new kinds of products and technological complementarities emerge.

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## Faculty Profile

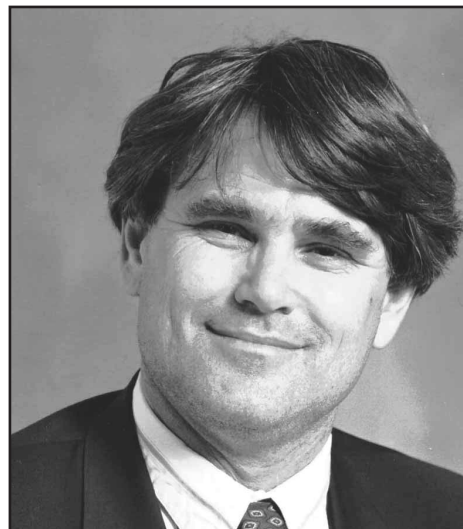
Scott Rozelle joined the Department of Agricultural and Resource Economics at UC Davis in 1997. He received his B.S. from UC Berkeley, and his M.S. and Ph.D. from Cornell University. He is a member of the American Economics Association, American Agricultural Economics Association, International Association for Agricultural Economists, Asian Studies Association and Association of Comparative Economics. Professor Rozelle has received numerous honors and awards in recognition of his outstanding achievements. One which is particularly noteworthy is the UC Davis 2000 Chancellor Fellow, an award given each year to one of the university's outstanding faculty members.

Dr. Rozelle's research focuses mostly on China and is concerned with three general themes: a) agricultural policy, including the supply, demand and trade in agricultural projects; b) the emergence and evolution of markets and other economic institutions in the transition process and their implications for equity and efficiency; and c) the economics of poverty and inequality. In one of his most recent projects, Scott is studying the impact that China's entry into the World Trade Organization will have on California's fruit and vegetable economy. He regularly talks to California farm groups.

In the past several years, his papers have been published in top academic journals, including *Science*, *Nature* and *American Economic Review*.

Scott is widely recognized as one of the leading economists in the U.S. with expertise on China's large and important agricultural sector. He is fluent in Chinese and has established a research program based on a knowledge and appreciation of China. He has close working ties with several Chinese collaborators. One of the prominent characteristics of Scott's work, and that of his students and collaborators, is that it is almost always based on survey work in the field. He is the chair of the International Advisory Board of the Center for Chinese Agricultural Policy, arguably China's most influential policy center.

In addition to his work on China, Dr. Rozelle also has travelled to and worked in many other countries around the Pacific Rim. For example, Scott and his students ran the first national survey of Papua New Guinea's rural economy for the World Bank. He has



*Scott Rozelle  
Professor*

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done field work in and published papers on Indonesia, Vietnam and the Philippines. He also has close collaborations with the International Rice Research Institute in the Philippines, the International Wheat and Maize Institute in Mexico and the International Water Management Institute in Sri Lanka. In South and Central America, Scott served as a Research Affiliate for CIMMYT, based in Mexico, and participated in the Comparative Study on Migration in China and Mexico.

The enrollment in development classes taught by Scott and his colleagues in the Development Field has expanded so rapidly that UC Davis professors now teach more undergraduates about the economics of developing countries than almost any other university in the nation. The graduate program in Development Economics is also thriving.

At home, Scott, a fifth generation Californian, primarily enjoys outdoor activities. He has a favorite sport in each season: skiing during the winter, tennis during the spring, playing baseball in the summer months, and fishing during the fall. Scott and his family also enjoy travelling to all corners of China, elsewhere in Asia, and to the rest of the world.

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## Prices, Volumes and Promotions in the Fresh Strawberry Market

by  
**Jessica Z. Jiang and Rachael E. Goodhue**

*Retailers prefer to promote fruits during their peak seasons. For strawberries, production and promotion peak in April and May. To increase demand for still-substantial strawberry volumes later in the season, the strawberry industry may wish to encourage joint promotions with other fruits.*

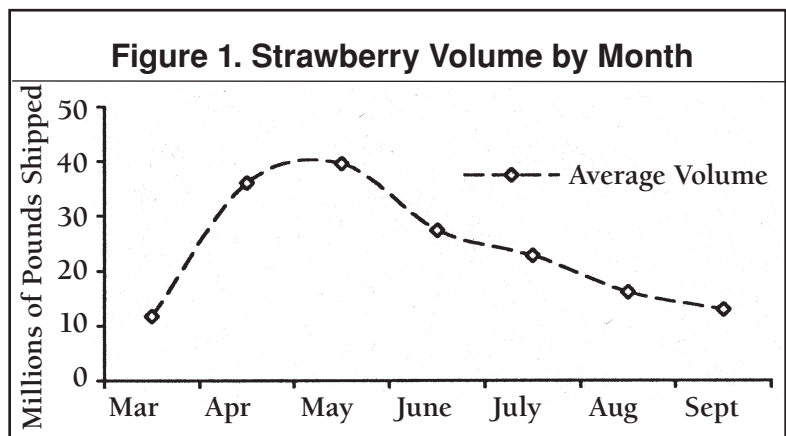
In fresh produce markets, producers and retailers' marketing risks are linked. Retailers wish to sell produce when it is still high quality. Producers wish to move their perishable product while it is still marketable. Timely, effective marketing is essential not only for the success of food retailers, but also for the success of producers and shippers. Closer coordination among shippers, producers and retailers may increase marketing effectiveness. This research is designed to increase strawberry producers and shippers' understanding of the factors influencing retailers' product promotion decisions and the demand for strawberries, so that they will be better able to make their own production and marketing decisions.

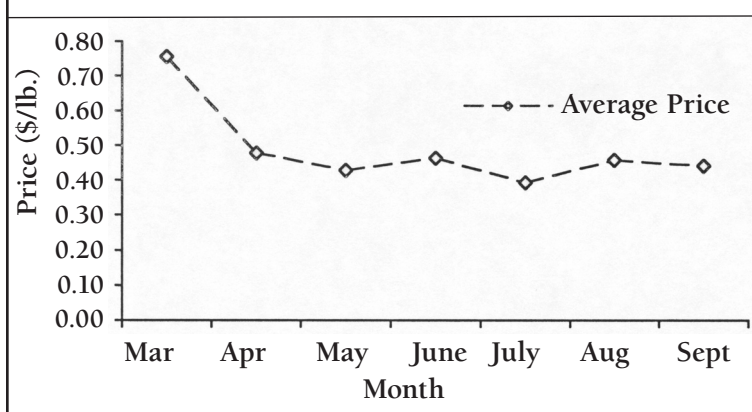
This research links observations from interviews with produce managers in local supermarkets in Davis, CA, with data regarding strawberry prices, volumes and promotions. Weekly fresh strawberry volumes and prices were obtained from various issues of *The Berry Report*, issued by the USDA's Federal State Market News Service. Information for *The Berry Report* is based on telephone surveys with shippers in the four California strawberry production regions and in Florida. Data regarding the percentage of market on ad were collected by Leemis Marketing and provided by the California Strawberry Commission. This variable measures the weekly percentage of retailers running strawberry promotions in their weekly newspaper supplements, and is based on monitoring of retailers in fifty major metropolitan regions. All data were collected over a nine-year period: 1990-1998. Since advertising data are only available for the months of March through September, we limit our analysis to this time period. These months account for the majority of fresh strawberry production in California.

Figure 1 indicates the average total volume of California strawberries produced each month in 1990-1998. Volume increases sharply from March to April, and increases further in May. It then slowly declines until September. Other things being equal, we would expect higher strawberry volumes to be associated with lower prices. Figure 2 reports the average price per pound of fresh California strawberries per month in 1990-1998. As expected, relatively low volumes in March are associated with relatively high prices. However, prices do not increase after June as volumes decline. Instead, price remains relatively constant.

The behavior of prices and volumes suggests that there are other factors influencing the demand for strawberries. One possible factor may be the availability of other fresh fruits. Strawberries are a relatively early fresh fruit. As cherries, peaches, plums, and other fresh fruits become available in June and July, consumers are less interested in purchasing strawberries to meet their fresh fruit needs. Thus, a lower price is needed in order to sell a given amount of strawberries in July than would be needed in April.

Here, we focus on a related factor: how do retailers' promotion decisions influence the price of fresh strawberries? The number of weeks that



**Figure 2. Strawberry Price by Month**

retailers promote strawberries varies between four and fifteen weeks in an average year, according to interviews. Like volumes, promotions tend to be seasonal. Since there are more strawberries available in the late spring and early summer, retailers tend to promote strawberries strongly at that time to attract customers to come into their stores.

Figure 3 illustrates that April and May are the peak promotional periods for strawberries, based on national data. Promotions decrease in August and September, when fewer strawberries are available. Based on this figure alone, it is difficult to infer any effect of promotions on prices, since the number of promotions follows the same pattern as fresh strawberry volume does.

Industry members hypothesize that more promotions increase the farm gate price of strawberries, and therefore, fewer promotions mean a lower price. However, this is not always true. Figure 4, which plots price according to the percent of market on ad, illustrates this point. For example, if we compare the price (\$0.45) for 8.5

percent market on ad versus the price (\$0.45) for 33.5 percent market on ad, we see that more advertisements per se do not increase the price of strawberries. This may be due to the confounding effects of volume, the effects of increases in the supply of other fresh fruits, or both. Figure 4 does not control for differences in these variables.

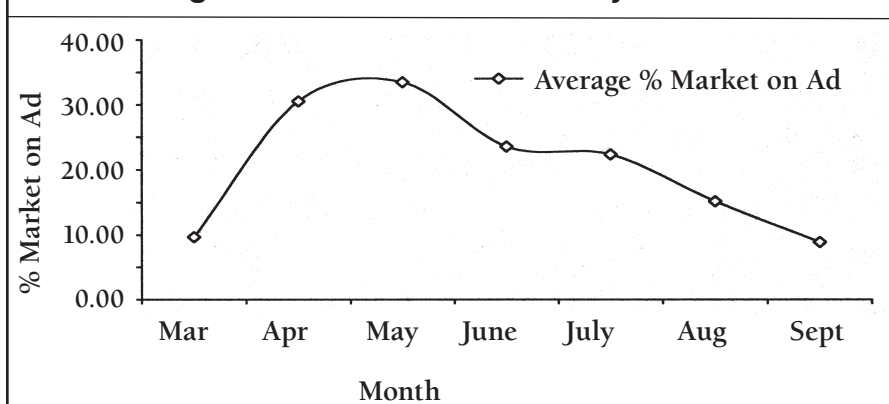
According to interviews, retailers prefer to promote strawberries during the peak harvest season, as suggested by Figure 3. This preference is confirmed in Figure 5, which shows that more promo-

tions are associated with a greater volume of strawberries. One hypothesis suggested by Figures 3 to 5 is that promotions increase the price of strawberries by encouraging consumers to purchase more when volumes are high. That is, promotions prevent the price of strawberries from declining as far as it would in the absence of the promotions. This is consistent with the percent of market on ad increasing, but maintaining a constant price, as shown in Figure 4. This possibility is an important one; following the peak harvest period, substantial volumes of strawberries are still produced in June and July, as seen in Figure 1.

The hypothesis that promotions mostly increase the price of strawberries at their seasonal peak and later in the season when volume is relatively high is supported by statistical analysis conducted by the strawberry research group in the agricultural and resource economics department at UC Davis. Strawberry advertising, measured as percent market on ad, had a positive effect on the price received by Watsonville strawberry growers, who produce at

the season peak and later, but did not affect the price received by growers in other regions, who tend to sell earlier in the season when strawberry prices are higher. (Results from Carter, Chalfant, Goodhue, and Xia. See the Spring, 1999 issue of *ARE Update* for a description of the seasonal pattern of strawberry production by Carter, Goodhue and Han.)

This relationship between promotions and prices suggests

**Fig 3. Percent Market on Ad by Month**

that during the period we analyzed, promotions primarily increased the price of strawberries during the peak harvest period and, perhaps, later in the season. That is, promotions raised prices when volume was high. Due to the pattern of total volume shown in Figure 1, the price of strawberries may increase if retailers undertook more promotions late in the season, when strawberry volumes are still substantial.

Interviews with industry participants indicate that it is difficult to induce retailers to plan promotions for July, August and September (although recently they have had some success in convincing them to do so). This observation is consistent with information from retailers: retailers prefer to promote all fresh fruits, not only strawberries, during their peak harvest seasons. Thus, as the year progresses and other fruits come into season, retailers choose to promote these other fruits instead of strawberries.



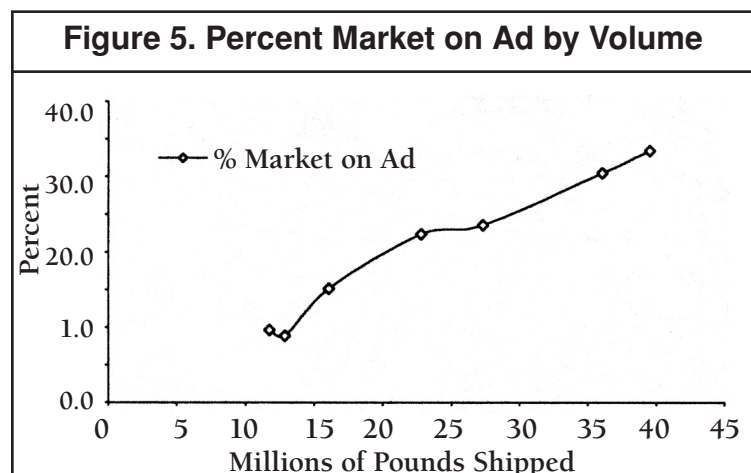
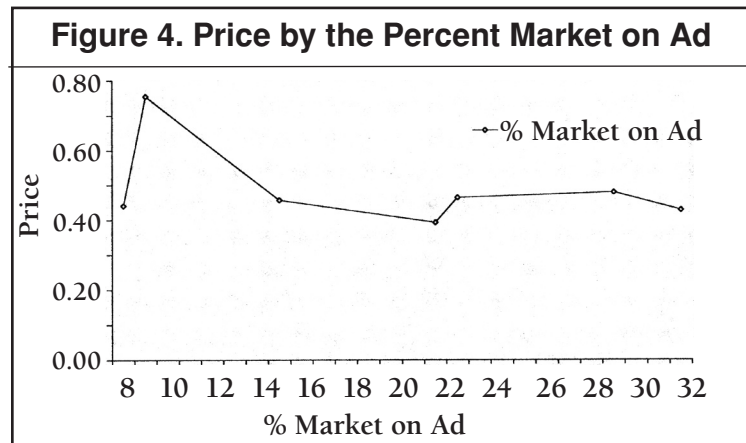
*Retailers prefer to promote strawberries during the peak harvest. This study suggests that joint promotions with other fruits may increase strawberry sales throughout the lengthy harvest season.*

*Photo by Rachael Goodhue*

Our analysis provides a potential strategy for strawberry growers to pursue in order to increase their revenues. Due to retailer strategies, it may

prove difficult to further increase promotions later in the season. Instead of promoting strawberries, retailers prefer to promote other fruits. We recommend that in addition to negotiating with retailers to increase their late season promotions, the strawberry industry attempt to engage in joint promotions with other fruits. For example, some retailers include recipes in their flyers. A recipe for strawberry-peach pies could be paired with promotions for those fruits. This strategy would recognize retailers' preference for promoting new fruits that are currently at their seasonal peaks, but would also have the potential to increase strawberry sales and prices.

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