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Bee-conomics Revisited: A Decade of New Data Is Consistent with the Market Hypothesis

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In the past decade almond acreage has expanded, causing growth in demand for honey bee pollination. However, pollination fees have fallen, indicating an even larger shift-out in the supply of honey bee pollination services and a reduction of marginal costs of pollination.

Honey bees have been much in the news for more than a decade. The observation of a puzzling and extreme winter die–off of honey bee hives in the United States was dubbed "colony collapse disorder" and captured the attention of scientists, industry members, and the general public. (The terms hive and colony are used interchangeably here, as in the literature.) Over the same decade, the continued rapid growth in the demand for honey bee pollination services by the California almond industry added to the importance of a better understanding of interactions among honey bees, pollination, and factors that drive pollination service supply and demand.

In 2006 Sumner and Boriss (2006) referred to the well–established and long–studied market for pollination services. They considered the rapid rise in pollination fees that had recently occurred for almonds and a few other crops in the context of basic economics. Sumner and Boriss pointed out that the prices and quantities of pollination services behaved much like other markets did when they experienced increases in marginal costs and expansion in demand. The present article reviews the current facts and market relationships for pollination from honey bees and highlights forces that may drive changes in pollination markets in coming years.

Economic Patterns and Relationships

Most honey bees are raised as domesticated livestock by commercial beekeepers. Commercial beekeepers migrate extensively, searching for pollination crops and forage sources. According to the United States Department of Agriculture (USDA), there were about 2.6 million colonies in the United States on January 1, 2016, of which 1.14 million were in California. During the almond bloom in 2016, California had a maximum of 1.4 million colonies. To illustrate hive migration, we note that California had 730,000 colonies in the state on July 1, 2015. In contrast, North Dakota had 460,000 hives present on July 1, 2015, but only 82,000 hives on January 1, 2016.

Honey bees contribute revenue to their beekeepers from three sources: pollination services, honey sales, and a set of miscellaneous products such as beeswax, propolis, and queens. In 2016 U.S. beekeepers had revenues of about $338 million from pollination, about $336 million from honey, and about $149 million from other products. Pollination is now the top income source and accounted for about 41% of 2016 revenue of beekeepers nationally.

Beekeepers tend to specialize among revenue-generating alternatives. According to the USDA Honey report, hives based in North Dakota and South Dakota together produced about $100 million in honey revenue in 2016, whereas in California only about $22 million was generated in honey revenue. Those beekeepers focusing on pollination services tend to get relatively little revenue from honey. Pollination revenue from

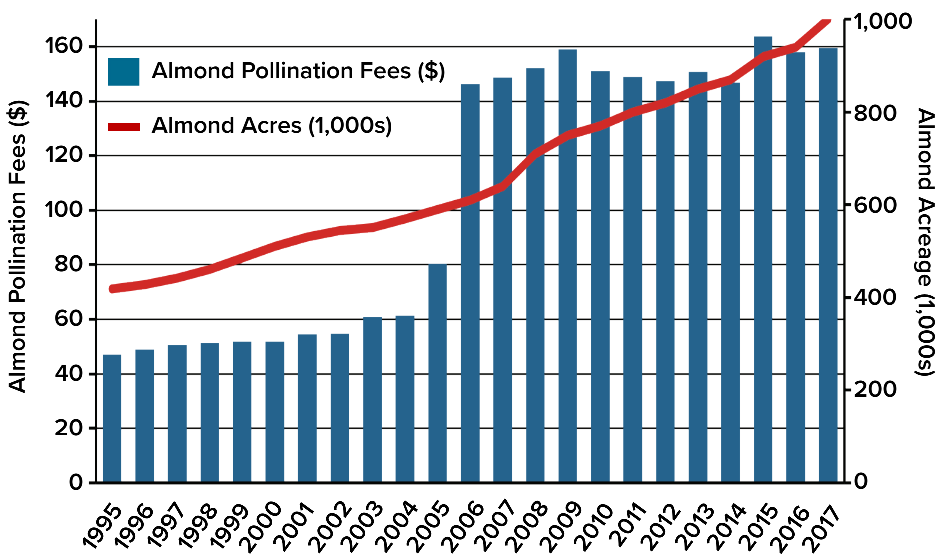

Figure 1. Almond Pollination Fees and Acreage, 1995–2017

Note: Pollination fees adjusted for inflation using GDP deflators with 2010=100
Source: California State Beekeepers Association (CSBA) pollination survey (various years) for fees and USDA National Agricultural Statistics Service (NASS) for acreage.

almonds was about $281 million in 2016, which was more than 90% of California pollination revenue and more than 80% of all pollination income nationwide.

Growth in the Importance of Almonds and Trends in Pollination Fees

Bearing acreage of almonds in California has grown steadily, from about 400,000 acres in 1995 to one million acres in 2017 (Figure 1). This growth implies that with two hives per acre, almond pollination required close to two million hives (USDA data vary on paid pollination acres of almonds, depending on the survey source). With about 300,000 acres of young trees to come into production in the next three years, the bearing acres in 2020 are likely to rise to more than 1.25 million acres, even allowing for removal of old trees. This rapid growth in almond acreage implies an equally rapid growth in demand for pollination services.

The bars in Figure 1 show, with reference to the left axis, that pollination service fees for almonds grew steadily in real terms (in 2010 dollars) from 1995 to 2005 as almond acreage also grew steadily. From just over $80 per hive in 2005, the pollination fee jumped about 80% in 2006. Since 2006, pollination fees for almonds drifted slightly to between $150 and $160 per hive and have not risen for more than a decade despite much larger almond acreage.

The jump in the 2006 pollination fee was likely caused by a sudden reduction in supply when the colony collapse disorder first appeared over that winter, which left the almond orchards with too few bees. The jump in fees was needed to draw bees out of other activities and from across the United States with little preparation time.

In the following years, the price has remained steady because an efficient system has quickly evolved to deliver bees to the expanding almond acreage, even with fluctuations in disease pressure on the honey bee industry. The fee of about $160 per colony is, together with income from other activities, to attract enough colonies to the almond pollination each February.

A further note about pollination fees is important. There is informal evidence that the number of active bees per colony has increased over the past decade. Colony strength is generally measured by "frame count," and pollination contracts are more likely now to specify minimum active frames per colony and contain financial incentives for more frames per colony. If frames per colony have risen since 2006, as those in the industry affirm, that means the fee per unit of pollination services has fallen by even more than the decline in fee per colony would indicate. The decline in fees per colony in the face of rapid steady increases in demand indicates that honey bees are more available than ever and the often–repeated claim of declining supply of pollinators does not apply to honey bees in the United States.

Seasonality, Honey, and Pollination Fees Across Crops

Seasonality and honey production are the important factors for understanding pollination fees across crops. Figure 2 presents the 2016 pollination fees per colony for California crops by the months of their flowering season. The shaded boxes are those crops that provide little or no marketable honey from pollination. Pollination fees range from $18 for prunes to $185 for plums, according to the Survey of the California State Beekeepers Association.

The earliest period, February and March, which is the period of peak demand from almond pollination, shows very high pollination fees for almonds and the crops that compete with almonds (early cherries and plums) during that pollination season. After almond pollination, beekeepers search for post–almond pollination contracts or safe foraging space. The crops that follow almonds demand at most 100,000 colonies, and relatively few pollination opportunities are available in other states. The post–almond pollination fee drops to its minimum of $18 for prunes just after the almond bloom. The difference in fees between plums and prunes exemplifies the importance of pollination seasonality.

The potential of honey revenue from a crop also seems to affect pollination fees, but the evidence is limited. The other factor is availability for safe forage for bees, so crops in regions with no dangerous pesticide use during the bloom have low or zero pollination fees. This may partly explain why alfalfa seed has relatively high pollination fees during the later spring and early summer season when non-honey crops have lower fees.

Emerging or Potential Drivers Affecting Bee-conomics in California

Costs of Supplying an Active Hive for Almond Pollination

Beekeepers face many challenges. The data illustrated in Figures 1 and 2 document the economic importance of almond pollination for the honey bee industry. Supplying about two million strong and active honey bee colonies to the almond orchards in February of each year is equally crucial for the economics of honey bees, and doing so is challenging and costly.

Honey bee disease management, control of mites and other pests, and effective and healthy long–distance transport are vitally important. The search for safe and secure forage before and after almond pollination, and cost–effective honey production, are also economic and management challenges facing beekeepers. The cost of hive splitting and creating replacement colonies and renovating colonies are also important for the supply-side of the pollination equation.

Slowing or Reversal of Demand Growth for Almonds

As almond acreage has grown, demand for honey bee pollinators has also grown in the approximately fixed ratio of two hives per bearing acre. As noted earlier, the number of active

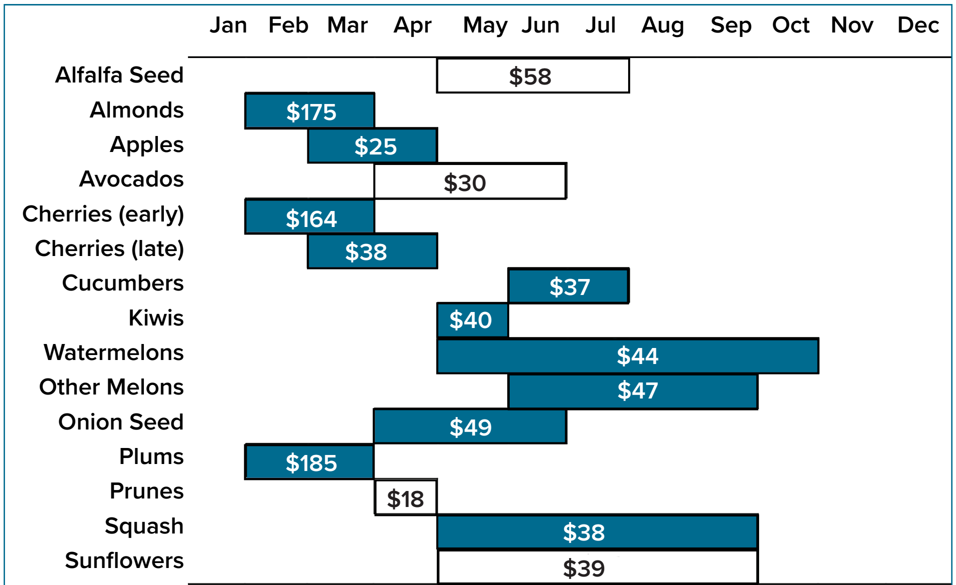

Figure 2. 2016 Pollination Fees Per Hive by Seasonality and by Crop's Honey-Producing Characteristics

Note: Darker shading indicates low honey production from the crop.

Source: 2016 CSBA pollination survey results for fees.
Various web sources are used for seasonality and honey producing capacity, including:
http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-90162011000600007
http://beeaware.org.au/pollination/pollinator-reliant-crops/onions/
http://www.beesource.com/forums/archive/index.php/t-227800.html

bees may have grown even faster as the average number of active frames per hive has risen. At the same time, almond production has risen rapidly with equally rapid growth in demand. Prices have fluctuated from $1.10 per pound in 2001 to $3.74 per pound in 2014 (in 2010 dollars), with several of the higher price years within the last five.

Despite this record of growth, there is no guarantee that demand growth will allow almond prices to remain high. Not only is competition from other nuts growing stronger, but many regions around the world are attempting to develop more acreage to compete with California's dominance of the world market. When almond acreage stops growing or even begins to recede, pollination prices and hive counts in almonds will recede. With about two-thirds of all commercial hives relying on almonds for a large share of their revenue, any almond reversal is serious for the population of honey bees.

Increase in Costs of Production or Resource Limits for Almonds

The most prominent supply-side issue facing almonds is the availability and cost of irrigation water in the San Joaquin Valley, where most almonds are grown. The most recent University of California Cost and Returns Studies for almonds (https://coststudies.ucdavis.edu/current/) show irrigation water accounting for between 13% and 33% of operating costs, depending on the cost of surface water and depth of groundwater. In contrast, pollination accounts for between 11% and 17% of operating costs.

Higher water costs or less reliability of water available for irrigation would halt growth or reduce acreage of almonds. Pressure from other crops increases as grapes, processing tomatoes, or alfalfa become more efficient in use of water, and compete for land and other resources. Almonds compete with dozens of other significant crops and there is nothing assured about the ability of almonds to dominate prospective crop profitability, especially if irrigation water availability becomes less secure.

Emergence of Self–Fertile Almond Varieties

Being "self–fertile" means that fruit setting does not require cross–variety pollination, resulting in much easier pollination with little requirement for honey bees or other insect pollinators. Self–fertile almond trees became commercially available more than a decade ago, and the variety "Independence" has recently gained popularity among those planting new almond orchards. Acreage planted to the Independence variety was a small share of bearing acreage in 2016, but accounted for almost 20% of the variety–identified, non–bearing acres (trees planted within the previous three years).

Of course, adoption of a variety is not driven solely by cost considerations because almond kernel characteristics are important to market price. How fast and to which extent self-fertile almonds will replace conventional high–pollination varieties remains uncertain. Yet, the emergence of this option would reduce pollination demand for a given almond acreage.

Concluding Remarks

This article documents and explains how honey bee pollination is a commercial enterprise and how patterns of pollination services and prices for those services follow standard expectations of supply and demand. The gradual decline of pollination fees for almonds (and other crops) in the face of continued increase in pollination acreage of almonds indicates increased availability of honey bees, not the decrease that one might expect from popular press accounts or even some of the scientific literature. The relevant data indicate more pollinators are available at lower fees, and in many places for much of the spring and summer, pollinators are available for very low or zero fees.

That is not to say that there are no environmental pressures on honey bees or wild pollinators. Commercial beekeepers have a challenging task in seeking safe foraging locations after almonds pollination. Moreover, wild pollinators, with no active manager, may be more vulnerable to environmental challenges. Entomologists, ecologists, and other researchers are now engaged in better understanding the vulnerabilities of both managed and wild pollinators.

The joint production of pollination services, honey, and other products has long been a significant commercial enterprise in California. The industry has grown rapidly along with the demand for pollination from expanding almond acreage. Total revenue of pollination services in California is now well above $300 million per year, with 90% from almond pollination. Almonds depend on honey bees and the size and economic health of the beekeeping industry depends crucially on the economic health of the almond industry.

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For additional information, the authors recommend:

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