Cornhusker Economics Agricultural Economics Department

1-18-2017

The Economic Impact of New Technology Adoption: An Example of the Role of Genetically Modified Technology

Lia Nogueira
University of Nebraska-Lincoln, lia.nogueira@unl.edu

AGRICULTURAL ECONOMICS

January 18, 2017

agecon.unl.edu/cornhuskereconomics

Cornhusker Economics

The Economic Impact of New Technology Adoption: An Example of the Role of Genetically Modified Technology

Market Report	Year Ago	4 Wks Ago	1-13-17
Livestock and Products, Weekly Average			
Nebraska Slaughter Steers, 35-65% Choice, Live Weight.	132.00	*	118.50
Nebraska Feeder Steers, Med. & Large Frame, 550-600 lb.	198.24	145.49	161.90
Nebraska Feeder Steers, Med. & Large Frame 750-800 lb.	165.76	137.76	135.71
Choice Boxed Beef, 600-750 lb. Carcass.	226.24	192.05	192.00
Western Corn Belt Base Hog Price Carcass, Negotiated	51.55	53.21	62.55
Pork Carcass Cutout, 185 lb. Carcass 51-52% Lean.	69.95	76.42	79.17
Slaughter Lambs, wooled and shorn, 135-165 lb. National.	143.71	138.63	141.01
National Carcass Lamb Cutout FOB.	359.79	350.69	346.52
Crops, Daily Spot Prices			
Wheat, No. 1, H.W. Imperial, bu.	3.93	2.72	3.11
Corn, No. 2, Yellow **Columbus**, bu.	3.33	3.06	3.17
Soybeans, No. 1, Yellow **Columbus,** bu.	8.21	9.29	9.51
Grain Sorghum, No.2, Yellow Dorchester, cwt.	5.48	4.70	4.83
Oats, No. 2, Heavy Minneapolis, Mn, bu.	2.66	2.97	3.05
Feed			
Alfalfa, Large Square Bales, Good to Premium, RFV 160-185 Northeast Nebraska, ton.	250.00	*	NA
Alfalfa, Large Rounds, Good Platte Valley, ton.	82.50	67.50	70.00
Grass Hay, Large Rounds, Good Nebraska, ton.	85.00	65.00	65.00
Dried Distillers Grains, 10% Moisture Nebraska Average.	134.50	110.00	107.50
Wet Distillers Grains, 65-70% Moisture Nebraska Average.	51.50	43.50	42.00
*** No Market**			

Fire blight is a bacterial disease that can affect various parts of the apple tree during different growth stages, including the blossom, fruit, roots and shoots. Fire blight outbreaks cause serious damage to apple producers. In 2000, Michigan lost more than 600 acres of orchards and more than 220,000 trees aged two to five years to the disease, leading to a loss of more than $42 million to the region (Norelli, Jones, and Aldwinckle, 2003). Typically in the United States, fire blight losses exceed $100 million annually. In this study, we evaluate new production technologies aimed at controlling fire blight in the U.S. apple industry using a temporal and spatial partial equilibrium model.

Many recently popular apple varieties are more susceptible to fire blight than the dominant traditional varieties, particularly 'Red Delicious' and 'Golden Delicious' (Briggs and Yoder, 2012). These highly susceptible varieties include favorites such as 'Fuji', 'Gala', 'Granny Smith', and 'Cripps Pink'. Growers of these susceptible varieties have suffered significant production losses from fire blight, which can be as large as 5% annually (Gianessi, Silvers, and Carpenter, 2002). As consumers substitute the susceptible varieties for traditional varieties ('Red Delicious' production in 2008 was only 65% of its 2000 level, while 'Cripps Pink' production nearly tripled in that same period), there is increased concern about the sustainability of production in regions where fire blight is prevalent.

Given current concerns about bacterial resistance to commonly used antibiotics, researchers are exploring ways to chemically and genetically reduce fire blight damage. Three important advances have been

UNIVERSITY OF Nebraska Lincoln

achieved in the past century to help control fire blight: rootstock breeding programs, the development of genetically engineered cultivars, and advances in chemical treatments (Norelli, Jones, and Aldwinckle, 2003).

The technology that is the base for our research focuses on short-term and long-term adjustments to production. Scientists involved in the Integrated Genomics and Management Systems for Control of Fire Blight research project are evaluating different strategies against the bacterium that causes the disease. In the short term, research is under way to generate an environmentally safe bio-control method that is more effective against fire blight than current treatments. Kim et al. (2012) obtained promising results using a microencapsulated bio-control agent, E325, to control fire blight. In the long term, scientists are working to identify fire blight resistant genes and develop fire blight resistant cultivars of preferred varieties that are currently highly susceptible. Wang, Korban, and Zhao (2010) highlighted some of their work in isolating the genes that express resistance to fire blight.

We develop a model to explore technology adoption and its effects on domestic and international apple markets. In particular, we analyze the potential costs and benefits of microencapsulation of a bio-control agent and genetically modified (GM) technology using an empirical, thirty-five-year temporal and spatial equilibrium model of orchard management. Our model generates a picture of the industry once the technology is available and can be adopted by growers in all regions. We specifically consider the perennial nature of the crop, the investment planting decisions of the growers, and interactions between U.S. and world markets through international trade.

Overall, we find that the adoption of GM technology can generate large profits for growers, especially when there are no restrictions on GM adoption. Our results are robust to yield gains from the GM technology (3% and 5%). Producers' welfare still increases if there is no GM maintenance cost reduction, but this is due to a switch to bio-control acres and not the production of GM acres. Generally, if consumers accept the GM technology, its benefits can exceed those of the bio-control method for producers. These results support the underlying motivation of technology use—to help limit production losses and reduce chemical inputs, which can lead to increased profits if the technology is adopted. The agricultural industry has experienced these benefits previously with the introduction of other GM technologies such as Bt cotton (Barnett and Gibson, 1999) and GM corn seed technologies (Brookes and Barfoot, 2005). Our results follow industry and project expectations.

Our analysis finds that, given the benefits of the technologies and the size of the U.S. apple industry, the research done by the scientists in the Integrated Genomics and Management Systems for Control of Fire Blight project has significant value to the industry. We find that the new technologies would bring more than $132 million to the U.S. apple industry over the thirty-five-year horizon. This value can be considered a willingness to invest in the development and implementation of the technologies to help stabilize and secure production. Our results provide estimates of what the technologies mean to the current apple industry when considering currently productive acres. However, there is potential beyond the acres currently in production, and further research could explore the direction that the industry could take on an even larger scale.

Following the release of technologically advanced foods, consumer opinion will have an important effect on consumption. In our analysis, we consider consumer hesitation about the GM technology through the rate in which producers adopt the technology. We consider how producers perceive consumer acceptance or hesitation through producer expectations about the demand for apples. Using an adoption rate quantifies potential producer hesitance about technology adoption, modeling producer anticipation of negative feedback from apple consumers, especially in the case of direct consumer interaction. This assumption improves our estimation of the potential technological impact to the industry. However, further research is needed on this topic.

We have provided evidence that through technology adoption the apple industry can thrive and consumers can benefit. When GM and bio-control technologies are adopted, fewer acres are required to meet demand. We show that maintenance cost reductions and recovering the production losses to fire blight are important to both producers and consumers. The release of the bio-control technology benefits growers and consumers both when there are producer adoption restrictions stemming from consumer concerns about GM products and when GM technology is fully accepted. Consumers see the benefits directly in the form of lower prices. Consumers also indirectly benefit in terms of a reduction of chemicals used on the crops, by design of the technology.

The GM and bio-control technologies have the potential to make a great impact on the U.S. apple industry. The technologies' effects on producer income will depend on the demand elasticity of apples. Typically, demand for fruits and vegetables is inelastic and needs a substantial price change to significantly impact the quantity demanded (U.S. Department of Agriculture, Economic Research Service, 2010). Consumption of fresh fruits and vegetables in the United States, however, is limited for families in lower income brackets, which may be an important determinant of demand inelasticity. Price could play a more important role in demand for apples if the demand elasticity for apples changes as consumer trends, income, or preferences change. Of course, the perennial nature of apple production stabilizes apple supply and makes it difficult for producers to respond to price changes in the short run. Even with the challenges of demand, a careful evaluation of the benefits from GM and bio-control technologies will enable the industry to successfully introduce those technologies. Perhaps the best option for the industry would be to introduce the technologies as a way to recover production while not distorting the market through more traditional government price support policies. Technology adoption can be marketed as stabilizing the industry by reducing fire blight outbreaks. Careful consideration must be made in the approach to consumers. Evaluating consumer benefits and comparing them to producer benefits will be critical to the market viability of the technology.

Consumer concerns about GM technology are inevitable, especially, for example, from parents buying food for their children. But unlike prevailing GM technologies that provide herbicide and pest resistance, which transfer genes between crop species, the fire blight technology transfers a gene between currently produced apple varieties. The FDA has already approved GM varieties of apples with characteristics preferred by consumers. Arctic Apple is one company that has recently had two varieties of non-browning GM apples approved (Nosowitz, 2015). These apples have been modified such that the enzyme that causes the browning of apples after slicing has been removed. They created a similar modification for potatoes that has also been FDA approved. Acceptance of GM soybeans, corn, and cotton is limited in much of the world, although U.S. consumers have come to accept these products. However, acceptance of directly consumable GM technologies could be a different story.

A survey of U.S. residents in 2014 by Lusk, McFadden, and Rickard (2015) provided some insight into the potential demand for genetically engineered food. They found that there is a level of acceptance for genetically engineered food for desirable characteristics such as nutrition, keeping production local, and lowering consumer prices. However, the results of the survey showed a more limited acceptance for less processed foods (Lusk, McFadden, and Rickard, 2015). Concerns are expected and research should be conducted to ensure the safety of consumers eating GM apple varieties.

Our research has implications beyond the U.S. apple industry, as it provides evidence of the true impact beyond production that government funding can have on an industry. The value of the impact and designations of beneficiaries help policy makers understand the impact that they can make. Further research in this area will define policy makers' impacts even more, and applications of these principles can be expanded to other industries to evaluate potential impacts for future research areas.

Funding for this project was provided in part by the U.S. Department of Agriculture (USDA)-National Institute of Food and Agriculture (NIFA)-Special Crop Research Initiative (SCRI) project no. AG 2009–51181–06023 and the National Institute of Food and Agriculture, U.S. Department of Agriculture, Hatch project 230404.

References

Barnett, B. J., and B. O. Gibson. "Economic Challenges of Transgenic Crops: The Case of 'Bt Cotton'." *Journal of Economic Issues* 33(1999):647–659.

Briggs, A. R., and K. S. Yoder. "WVU-KTFREC Apple Fire Blight Susceptibility Table." 2012. Available online at http://www.caf.wvu.edu/kearneysville/tables/fbsus.html.

Brookes, G., and P. Barfoot. "GM Crops: The Global Economic and Environmental Impact—The First Nine Years 1996–2004." *AgBioForum* 8(2005):187–196.

Gianessi, L., C. Silvers, and J. Carpenter. *Plant Biotechnology: Current and Potential Impacts for Improving Pest Management in US Agriculture. An Analysis of 40 Case Studies.* Washington, DC: National Center for Food and Agricultural Policy, 2002. Available online at http://biotechbenefits.croplife.org/paper/plant-biotechnology-current-and-potential-impact-for-improving-pest-management-in-u-s-agriculture-an-analysis-of-40-case-studies/.

Kim, I.-Y., P. L. Pusey, Y. Zhao, S. S. Korban, H. Choi, and K. K. Kim. "Controlled Release of *Pantoea agglomerans* E325 for Biocontrol of Fire Blight Disease of Apple." *Journal of Controlled Release* 161 (2012):109–115. doi: 10.1016/j.jconrel.2012.03.028.

Lusk, J. L., B. R. McFadden, and B. J. Rickard. "Which Biotech Foods Are Most Acceptable to the Public?" *Biotechnology Journal* 10(2015):13–16. doi: 10.1002/biot.201400561.

Norelli, J. L., A. L. Jones, and H. S. Aldwinckle. "Fire Blight Management in the Twenty-first Century: Using New Technologies that Enhance Host Resistance in Apple." *Plant Disease* 87(2003):756–765. doi: 10.1094/PDIS.2003.87.7.756.

Nosowitz, D. "FDA Approves GMO Apples and Potatoes." 2015. Available online at http://modernfarmer.com/2015/03/fda-approves-gmo-apples-and-potatoes/.

U.S. Department of Agriculture, Economic Research Service. "International Food Consumption Patterns." 2010. Available online at http://www.ers.usda.gov/data-products/international-foodconsumption-patterns.aspx.

Wang, D., S. S. Korban, and Y. Zhao. "Molecular Signature of Differential Virulence in Natural Isolates of *Erwinia amylovora*." *Phytopathology* 100(2010):192–198. doi: 10.1094/PHYTO- 100-2-0192.

This article is based on:

Busdieker-Jesse, N.L., L. Nogueira, H. Onal and D.S. Bullock. 2016. "The Economic Impact of New Technology Adoption on the U.S. Apple Industry." *Journal of Agricultural and Resource Economics* 41(3):549-569.

Lia Nogueira
Assistant Professor
Department of Agricultural Economics
University of Nebraska-Lincoln
lia.nogueira@unl.edu