CARD Agricultural Policy Review
IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY
Ames, Iowa • Spring 2014

Technology and Productivity in US Corn and Soybean

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COMPETING DEMANDS from food, feed, energy, and environmental uses are placing stress on global land resources. To deal with these challenges, much hope rests on sustaining the trend of past productivity growth by developing and adopting new technologies. In this context, there is much to learn from the US experience of tremendous yield gains achieved thanks to improved crop varieties and management practices.

Research at CARD has reexamined the statistical evidence concerning corn and soybean yields. The data used are county-level average yields from the USDA for the period 1964–2010 for non-irrigated agriculture in all US counties with significant production of these two crops. The main objective was to isolate the specific contribution of the adoption of genetically engineered (GE) varieties from other key determinants, including germplasm improvement attributable to traditional breeding, and weather conditions. To measure weather impacts, daily temperatures from the nearest weather station were used to construct monthly growing degree days variables (useful temperatures in the range of 50–86 degrees), and also excess heat degree days variables (harmful temperatures in excess of 90 degrees). We also accounted for the impact of water stress via a monthly Palmer index (which measures soil moisture relative to normal conditions). The model also included the changing pattern of nitrogen application over the period studied.

Our results confirm the importance of weather effects on yield, a reminder of the uncertainties and risks associated with the prospect of climate change. For both corn and soybeans, we found a positive response of yields to growing degree days and a strong negative response to excess heat. For moisture, the results show that production benefits from a dry spring and a dry harvest season, other things equal, and ample moisture in the summer months enhances yield. Increased nitrogen fertilization has also contributed significantly to yield increases, particularly for corn—the US average nitrogen application rate increased from 49 lbs/acre in 1964 to its peak of 136 lbs/acre in 1985 (it has leveled off since then).

Once weather, fertilization, and county-specific differences in soil productivity are accounted for, the remaining systematic trend in yield can be attributed to the role of improved varieties. The assumption that underlying germplasm improvement due to traditional breeding has contributed the same yield advantage both before and after the introduction of GE traits in 1996 permits us to isolate the specific yield impact of widespread GE variety adoption.

Regional differences exist, not only for yield levels but also for rate of growth. Here, we specifically discuss the results pertaining to the central Corn Belt (CCB)—Iowa, Illinois, and Indiana. These states experienced a stronger growth for both corn and soybean yields than the rest of the country (although the pattern was similar for all US growing regions). We find that during the period 1964–2010, corn yields increased on average by 1.35 bushels per acre per year without accounting for the impact of GE trait adoption. The latter appears to have made a major contribution to corn yields: going from zero adoption to complete adoption, the model implies that GE traits contribute an additional total yield gain of 20.8 bushels/acre.

The results are similar for soybeans, as far as the underlying trend is concerned. In the CCB, the estimated growth of soybean yields was on average 0.46 bushels per acre per year over the period considered.

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The adoption of GE varieties does not appear to have benefited soybean yields, however. In fact, the model suggests that complete adoption of the Roundup-ready trait by itself leads to a decline of 1.1 bushels/acre.

Decoupling the impact of the underlying germplasm improvement from the GE trait contribution in this manner relies on some modeling assumptions, and slightly different results are possible by changing the structure of the model. Combining the estimated effects of traditional breeding with the additional impact of GE varieties, the model was used to estimate the total predicted growth in yields over the period 2011–2030 that should be expected for normal weather realizations. Expressed as a percentage of the realized yield in 2010, the model suggests a total growth of average yields in the CCB over this 20-year period ranging between 18.7% and 31.8% for corn, and between 16.7% and 18.2% for soybeans.

The study confirms the key role of technology in sustaining productivity improvements in agriculture. Yield gains in corn and soybeans are the result of continuous breeding efforts over a long period of time, a process accelerated by the advent of biotechnology, leading to the introduction and widespread adoption of GE traits. Improved inputs go hand-in-hand with improved management practices. We noted earlier the key role played by nitrogen fertilization in corn yields. Another key practice enabled by the development of modern varieties concerns seeds density, which has been steadily increasing for corn: the average planting density in the United States went from about 26,000 kernels/acre in 1995 to about 30,000 kernels/acre in 2011. As for future impacts of technology on farm practices, much interest at present surrounds the use of "big data" in agriculture whereby modern information technology is used to combine knowledge of crop attributes with data on localized soil conditions and weather forecasts, in order to provide real-time prescriptive management advice at planting and through the growing season.

Realized yields at the farm level are the result of a complex process that includes genetic improvement of plant varieties, their interaction with many environmental factors, and continually improving agricultural practices and farmers' decisions driven by market conditions.

Improvements in agricultural productivity are essential in the pursuit of global food security given the challenges of population growth, climate uncertainties, environmental stress, and land degradation, as well as the expansion of land used for non-food (energy) production. Realized yields at the farm level are the result of a complex process that includes genetic improvement of plant varieties, their interaction with many environmental factors, and continually improving agricultural practices and farmers' decisions driven by market conditions. All these elements need to be better understood if the impressive productivity successes of the past are to be repeated in the future. In particular, research and innovation is key to securing the desired yield gains, and advances in biotechnology are bound to play a critical role. Policies supportive of such research, both at public universities and in industry, are vital to enable much needed continuing productivity growth in agriculture. ■

For more information, see:

Xu, Z., D.A. Hennessy, K. Sardana, and G. Moschini. 2013. "The Realized Yield Effect of Genetically Engineered Crops: U.S. Maize and Soybean." *Crop Science* 53: 735–745.

Inside this issue

Technology and Productivity in US Corn and Soybean 1
Can the Trend of Rural Population Decline Be Reversed? 3
Can Voluntary Adoption of Agricultural Practices Achieve the Hypoxic Zone Reduction Goals? 5
Another Strong Quarter for Agricultural Demands 6
Hog Markets and the Porcine Epidemic Diarrhea Virus 9
Ask an Ag Economist 12

Can the Trend of Rural Population Decline Be Reversed?

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IN 1900, Iowa's rural population was just shy of 1.7 million, with almost three-fourths residing on farms or in small towns. However, with the exception of the 1990s, Iowa's rural population has declined in every census over the last 110 years, as shown in Figure 1. By 2010, only 36% of Iowans remained in rural areas.

Numerous policies have been proposed to stem the decline of Iowa's rural population. Over the past decade, these have included fostering rural entrepreneurship, promoting rural manufacturing, beautifying town centers, and expanding rural broadband. While any of these might have some positive impacts, it is difficult to believe that they will reverse the century-long rural-to-urban population shift.

The prominent question is not what can be done to reverse the rural population decline, but rather, thus far, what has allowed Iowa to maintain so much of its rural population compared to other states? Iowa is the 12th most rural state in the country, and in contrast, Nebraska is the 23rd most rural state. Despite having a land mass that is 99.2% rural, 73% of Nebraska's population lives in urban areas, compared to Iowa's 64% urban population.

With a population of 4,192, Adams County is the least populous county in Iowa; however, 33 of Nebraska's 93 counties have a population less than that of Adams. In Iowa, 50% of the population lives in the 12 largest counties, however 50% of Nebraska's population lives in only three counties. Iowa has 36 counties with populations of at least 20,000, representing 75% of its entire population; in contrast, Nebraska has only 17 counties with populations of at least 20,000, representing 76% of its entire population.

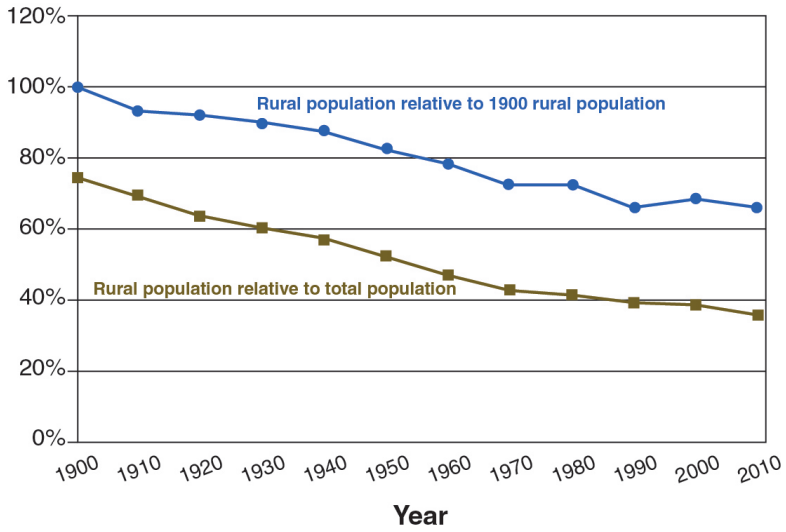


Figure 1: Iowa rural population, 1900–2010

The reason Iowa can sustain a more rural population than can Nebraska is the larger number and broader distribution of metropolitan areas (cities of at least 50,000). Whereas Nebraska has only four metropolitan areas (Lincoln, Grand Island, Sioux City, Omaha), all of which are in the far eastern part of the state, Iowa has nine metropolitan areas broadly distributed around the state, including two shared with Nebraska. Nebraskans wanting to take advantage of the 20% wage premium paid in urban labor markets have to live in or near one of the four metropolitan areas. In contrast, the distribution of metropolitan areas in Iowa places about 90% of the population within a 45-minute commute of an urban labor market. As a result, almost three-fourths of residents of towns with populations under 2,500 commute to another town for work. Iowa's small towns are surviving compared to those in Nebraska because small town Iowans can access the higher urban wages while taking advantage of the lower cost of living available in small towns.

A wealth of research has documented that urban firms have significant advantages over rural firms in terms of productivity, infrastructure, proximity to customers, access to financing and educated labor, and other so-called agglomeration economies, which has allowed faster growth than rural firms despite higher land and labor costs. These advantages are not new—economist Alfred Marshall wrote about the advantages of urban firms in 1890, about the time Iowa's rural population reached its historic peak.

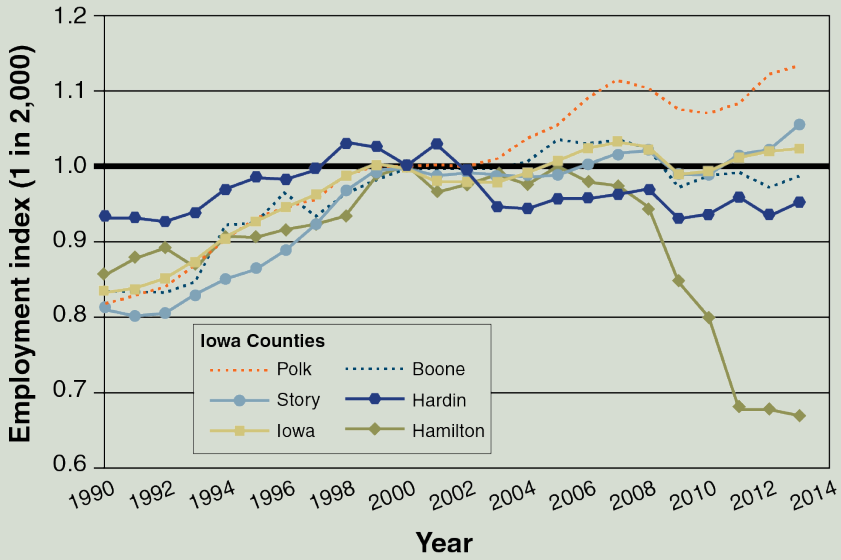
So what does Iowa need to do to preserve competitive small towns? We need to continue fostering growth in urban markets and ensure that we have good commuting roads from metropolitan areas to surrounding small towns. Research done at Iowa State has shown that job growth in one county leads to population growth in a

two county radius. It was also found that agglomeration economies are important for new firm entry even in rural areas, meaning local labor centers such as Carroll can attract firms, and small towns within a two-county radius can rely on Carroll for jobs. Findings also suggest that access to high-speed internet attracts new firm entry when the community is within close distance to an urban market. Therefore, efforts to bring high-speed internet to remote towns will have a smaller impact on job growth—firms still need to be close to their customers, or at least close to a FedEx or UPS hub. (The largest shipper of live lobsters in the world is in Louisville, KY because it is a hub for UPS.)

Not all rural Iowa towns are doing well—some have suffered severe firm, employment, and population losses; however, the most disadvantaged are all too great a distance from an urban market. Even as small towns face future firm losses their recovery and survival will increasingly depend on the ability to access an urban labor market. As an example, the closing of the Electrolux plant in Webster City had a huge impact on employment in all of Hamilton County, as shown in Figure 2. While other counties near Hamilton County, and Iowa as a whole, have experienced some employment growth or else just modest declines, Hamilton County lost one-third of its jobs over 10 years. Since the Electrolux plant closing jobs have continued to leave Hamilton County—the unemployment rate, which had never been high relative to the state level, surged to 10% by 2011.

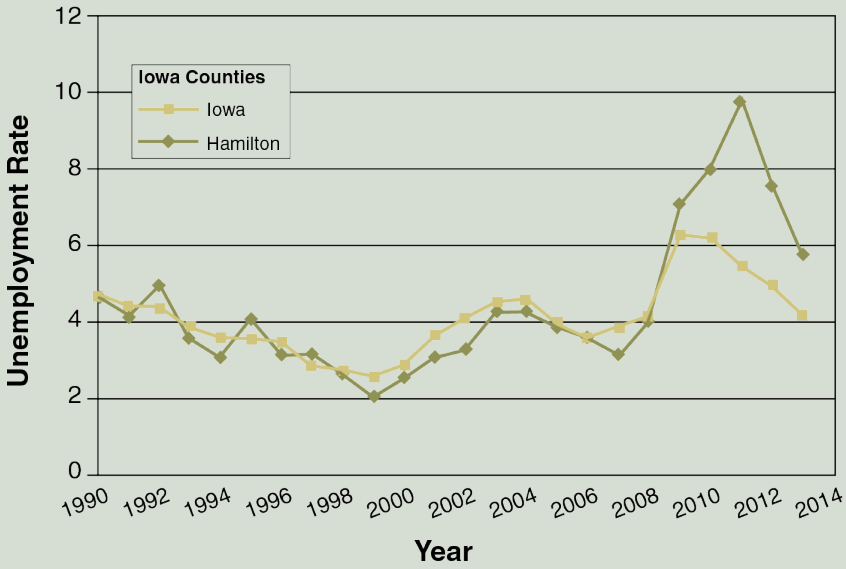
Since 2011, however, the Hamilton County unemployment rate has come down sharply to 5.3%. The number of Hamilton County residents employed increased by 7% in 2013, even though job loss has continued (Figure 3). The reason? Displaced workers in Hamilton County have found jobs in neighboring counties, especially in the surging Story County labor market. Without the availability of jobs in Story and Polk counties, many more Webster City residents would have had to move to find work.

Iowa's rural and urban politicians are often at odds regarding economic development strategies, with rural politicians viewing urban employment growth as a threat. In fact, the growth of Iowa's urban job centers has meant the survival of small Iowa towns more than any programs aimed at creating jobs in rural towns. ■



Source: www.iowaworkforce.org/lmi/empstat/msanonag.htm

Figure 2: Employment growth in Iowa and Central Iowa counties, 1990–2013



Source: www.iowaworkforce.org/lmi/empstat/msanonag.htm

Figure 3: Unemployment rates in Hamilton County and the State of Iowa, 1990–2013

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Can Voluntary Adoption of Agricultural Practices Achieve the Hypoxic Zone Reduction Goals?

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THE PRESENCE of a "dead zone" in the Gulf of Mexico caused by nutrients (nitrogen and phosphorus) coming from upstream watersheds continues to recur annually. As part of the 2008 action plan promulgated by the Hypoxia Task Force (http://water.epa.gov/type/watersheds/named/msbasin/index.cfm) to address the problem, each state with major nutrient contributions to the Gulf was tasked with developing and implementing a nutrient reduction strategy. Most of the 12 states included have begun or completed their plans. A common theme among all states is the focus on voluntary adoption of the practices identified rather than a regulatory strategy.

In addition to identifying the conservation practices that will be most cost effective in their region, some state plans are also identifying the coverage of the identified practices that will be necessary to achieve the target reductions in nitrogen and phosphorus. These "scenarios" are extremely helpful in understanding the extent of the change needed on the landscape to achieve the goals of the Hypoxia Task Force. For example, as the Iowa Nutrient Reduction Strategy indicates, to achieve the targeted nitrogen and phosphorous reduction goals, over 90% of the 21 million acres of row crop agricultural land will need to be treated with practices ranging from improved nutrient management, cover crops, bioreactors and/or wetland installation or other equally effective approaches. Can a voluntary approach lead to this extensive adoption of these practices?

To consider this question, imagine a situation where there is no cost share or compensation for farmers/landowners to adopt new practices. Even in this case, there are a number of possible benefits that these practices might generate to induce adoption. Like most businesses, farmers compete in a competitive and uncertain environment. Any conservation actions that improve profitability without increasing risk will be appealing. A practice that either increases yield, lowers the cost of production, or both fits this category. A great example is the use of reduced or no till, which, under the right circumstances, can lower input costs and increase yield over the long run. Indeed, we have seen farmers in many locations adopt this practice with no financial compensation. A second category of on-farm benefits can come from practices that reduce risk or save time during particularly busy portions of the season. An example of the former can be precision application of nutrients. A third type of benefit a farmer might receive from conservation actions is the enjoyment that comes from nearby wildlife habitat, production of windbreaks, aesthetic appreciation, or other environmental benefit. Buffers, wetlands, and perennial grasses provide these benefits. Finally, farmers may receive benefits in the form of satisfaction from improving their environmental performance.

USDA-ARS

Of course, in the situation where there is no cost share or compensation for the adoption of these practices, there will typically be some costs of adoption. First are costs that directly come from the bottom line, reducing profit. Many conservation practices, particularly structural practices, have significant installation and maintenance costs associated with them. In addition to terraces, wetland restoration, and buffers, new practices such as bioreactors fall into this category. The second way in which the bottom line can be directly impacted is through lower yields. For example, it appears that cover crops may sometimes reduce yield, and any practices that take land out of production, such as buffers, will require forgoing production on part of the land. A third type of costs that farmers can face with conservation practices is increased risk or management time. For example, reduced tillage in locations that are cool or wet can increase risk, and

continued on page 8

Another Strong Quarter for Agricultural Demands

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AGRICULTURAL DEMAND has remained strong through the first half of 2014. Crop and livestock prices have provided good returns because of strong demand. As we move into the summer season, live cattle prices have moved into the $140–$150 range. Feeder cattle prices have topped $200 per hundredweight; and lean hogs have approached nearly $130 per hundredweight. Also, corn and soybean prices offered crop producers positive profit margins during the planting season.

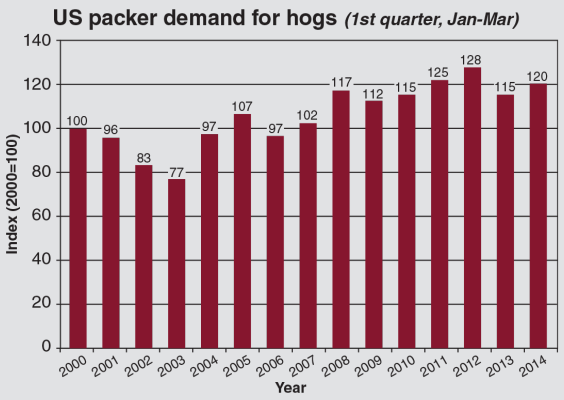
Strong demand for agricultural products has come from both domestic and international sources. Crop and meat export demand has been stronger than in past years. For domestic demand, biofuel demand has increased in recent months. The continuation of the strong demand is key for profit prospects as we move into the second half of 2014.

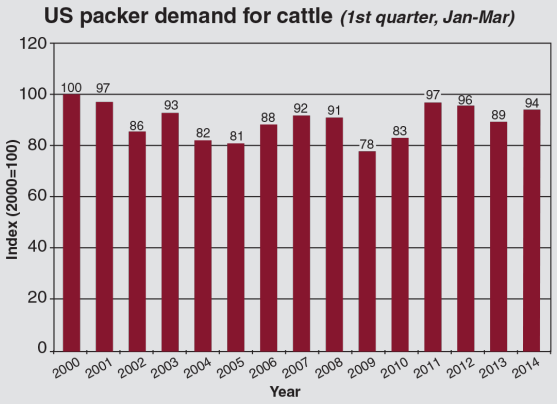
Starting with the livestock packing industry, demand for US hogs, mainly driven by prices, has been on the upswing during the first three months of the year. While year-to-year consumption has fallen, price increases in the past six months have been more than enough to increase hog demand. As it now stands, the first quarter of 2014 has the third-highest demand for hogs in the last 15 years.

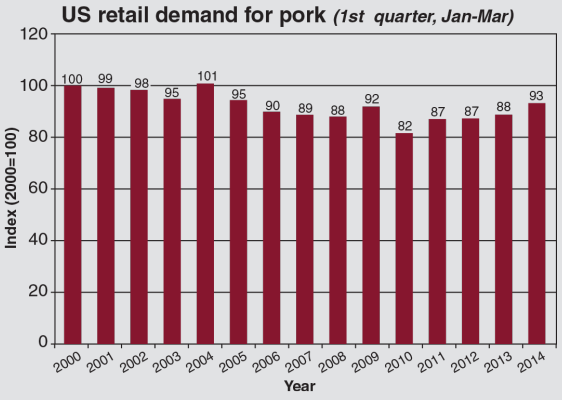
The cattle industry parallels the growth in hog demand from packers. First quarter demand for cattle has risen significantly from last year. As with hogs, while consumption is down, prices have risen more than enough to result in an increase in demand. In fact, cattle prices continue to set record highs.

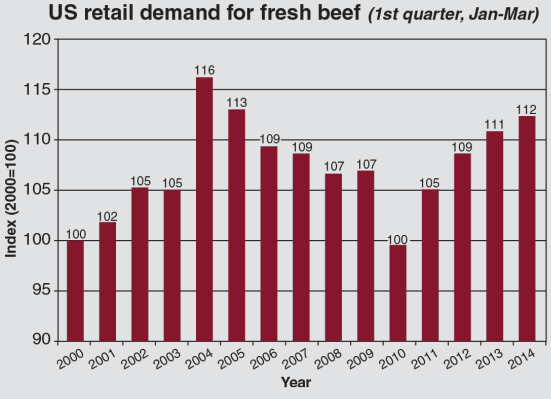
However, as we've mentioned in previous articles, the answer to a major question for packers—whether they could transfer these higher livestock prices to the retail counter—has been yes. US consumers have continued to purchase meat products, allowing both retail pork and beef demand to increase. For pork, the jump in demand was substantial this previous quarter. While year-to-year consumption fell by just over 1%, the real price for pork (adjusted for inflation) rose by nearly 7%—a $.30 per pound increase in the price of pork over the past year. US consumers have been absorbing, for the most part, the livestock and meat price increase.

For beef, the demand increase was smaller, but the basic story remains the same. Consumption decreased slightly, but that decrease was more than offset by price increases. Per capita consumption fell 4% to 13.13 pounds for the quarter, while beef retail price rose 5%. The nominal price for beef topped $5.50 per pound for the first time. Retail beef demand is the strongest it has been since 2005, before the slide into the recession.







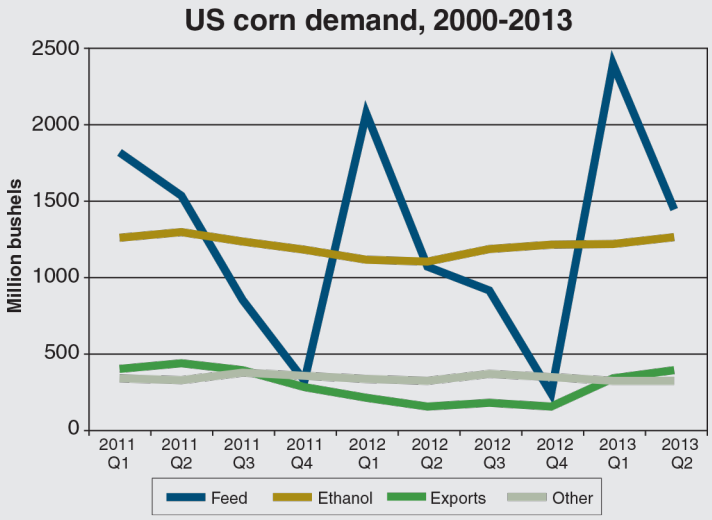


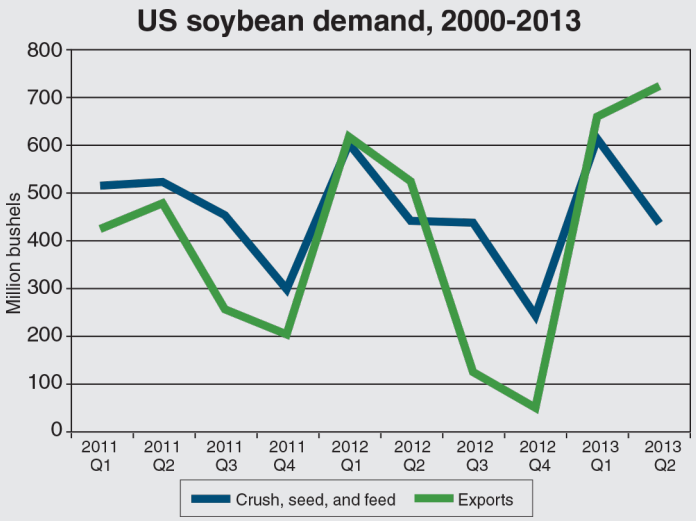
All in all, the demand picture is very good for the livestock industry. Prices are strong, but consumers have been willing to pay the higher prices. Since 2010, retail meat demand has been on the upswing. Both livestock producers and packers hope that pattern continues.

Shifting to the crop sector, the major story has been the strong pace of soybean exports. Normally, the 1st quarter of the marketing year (September–November for both corn and soybeans, as the marketing started on September 1 of last year) is the strongest quarter for export demand as the crops are plentiful and prices tend to be lower. However, this past 2nd quarter (December 2013–February 2014) was the strongest export demand quarter ever. Over 700 million bushels of soybeans were shipped out of the US during the quarter. That surge in export demand helped propel the soybean market into a significant rally this spring, and, while domestic demand for soybeans did retreat, it basically paralleled last year's decline.

For corn, while feed demand followed its traditional drop in the 2nd quarter, ethanol and export demand rose. The ethanol demand increase is being driven by higher energy prices in general, a relatively lower cost for corn, and improving export markets for ethanol. In the first three months of 2014, the US has exported nearly 250 million gallons of ethanol, with Brazil and Canada being the major purchasers. However, the ethanol demand has a fairly broad base of support, as countries such as the United Arab Emirates, Philippines, Netherlands, Jamaica, Nigeria, and South Korea have all bought ethanol from the United States. Direct export demand for corn also increased, with Mexico and Japan leading the charge. China had been a major player for corn demand in the 1st quarter of the marketing year, but the trade dispute over genetically modified strains of corn has dampened and continues to cloud that market. However, as China has retreated, other importing countries have stepped up demand for corn.

Overall, the demand for Iowa's basic agricultural products is very strong on the livestock side and at record levels on the crop side. That strong demand continues to support record-high prices for livestock and has provided marketing opportunities for crop producers. The major difference between the two sectors is the expected supplies for the coming year. While livestock producers are ramping up production, livestock numbers are still smaller than they have been in the past. On the other hand, corn and soybean production is projected to be at record levels this fall. Therefore, livestock producers are likely to enjoy high prices throughout the rest of the year, while crop producers are already feeling the pinch of lower prices, even though both sectors have good demand prospects. ■





precision agriculture generally requires more time for proper management. Finally, there may be practices that are aesthetically unappealing to a farmer, increase pest pressure or have other undesirable side effects. All of these components can be considered costs of a practice.

Having considered the range of on-farm costs and benefits of conservation practices, let's return to the question of whether voluntary adoption (in the absence of any financial compensation) is likely to result in the adoption of practices needed to achieve the goals of the Hypoxia Task Force. If farmers can generally be expected to voluntarily adopt the practices for which the benefits they receive exceed the costs they incur, which practices pass this "benefit-cost" test?

Iowa Strategy

In the Iowa Strategy, three scenarios are identified that would achieve the goals of the Hypoxia Task Force. The primary practices in these scenarios include conservation tillage, reduced nitrogen application rates, increased use of side dressing, cover crops, wetlands, buffers, controlled drainage, and bioreactors. Of these, conservation tillage and alterations in nitrogen application rates and timing have the greatest potential to increase profitability at the farm level. Numerous studies suggest that in the right locations, conservation tillage can lower cost and increase average yields, and changes in nitrogen application rates and timing can lower cost. However these practices alone are likely to achieve only a modest (less than 9%) reduction in nutrients, far short of the 40% reduction goal for agriculture. Will voluntary adoption of other practices make up the difference?

Because cover crops are relatively new to the Midwest, we are still learning about the on-farm benefits and costs. On-farm benefits could include improved soil health and therefore improved yields in the long run. However, this must be balanced against direct annual costs of $30 or more per acre. While the jury is still out, yield increases will need to be substantial and sustained for benefits to outweigh the costs, at least with current prices and technology.

. . . if new markets are developed for cover crop varieties, this could change the on-farm benefit cost calculus quickly in favor of expansive adoption.

Wetlands are a relatively expensive option as they require taking land out of production as well as restoring the area. They do, however, provide a suite of ecosystem services outside of water quality improvement, some of which will accrue to farmers and landowners. However, many of these values accrue to off-site beneficiaries and the high costs of wetlands make voluntary large scale adoption unlikely. Buffers could be considered to fall into this same category.

Finally, bioreactors and a variety of forms of drainage management are being developed that are particularly effective at controlling the loss of nitrogen. In addition to being expensive, the primary benefits of these practices are to improve water quality downstream; hence there is little hope that the on-farm benefits will exceed the costs of adoption.

If the above characterization of costs and benefits to farmers/landowners from the needed conservation practices is roughly correct, then purely voluntary adoption of conservation practices seem unlikely to achieve the goals set forth by the Hypoxia Task Force. Of course, one option is for cost share or direct compensation of the costs to be covered by government or NGOs. The United States has a long history of providing financial assistance to farmers and landowners for conservation via federal and state programs. However, the costs of such an approach are striking: for Iowa alone the Nutrient Reduction Strategy reports that these costs could be from $80 million to $1.4 billion annually. It seems unrealistic to think that funding amounts of this size will become available.

Incentives

Are there other options? First, as improvements are made in cover crop varieties and more experience with them is gained, there may be opportunities to lower the costs and benefits towards a higher adoption rate. Second, there may be some locations in the state where limited water quality trading or other innovative approaches could make some progress, but such opportunities are likely to be limited in scope. Finally, new markets and opportunities for alternative crops could be game changers. For example, if perennial crops become commercially viable as biofuel feedstocks, rapid and extensive adoption could follow—their perennial nature makes these crops very effective at nutrient and sediment retention. Likewise, if new markets are developed for cover crop varieties, this could change the on-farm benefit cost calculus quickly in favor of expansive adoption. ■

Hog Markets and the Porcine Epidemic Diarrhea Virus

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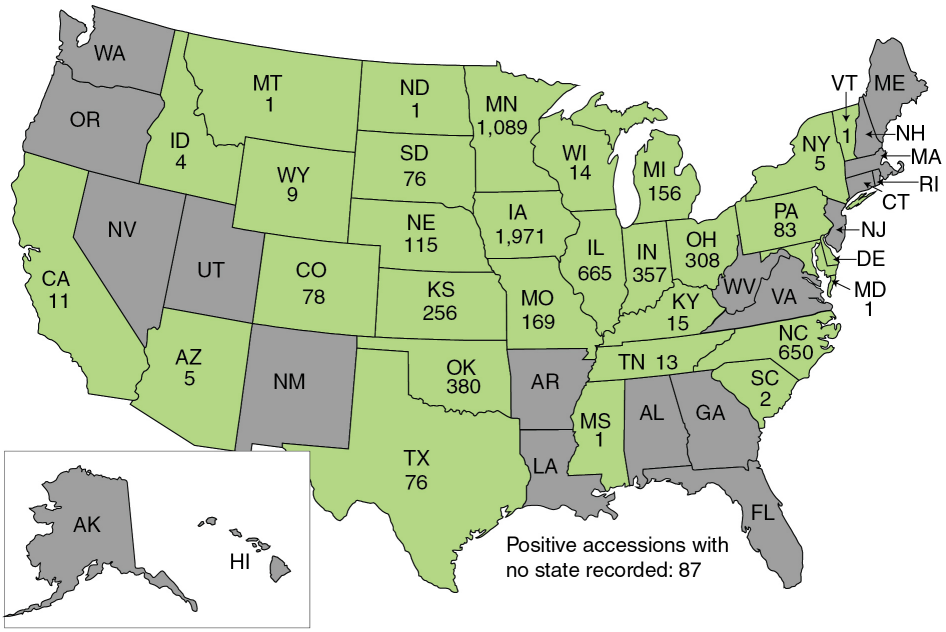
PORCINE EPIDEMIC Diarrhea Virus (PEDv) has spread rapidly through the United States swine herd since initial diagnosis in spring 2013. By May 2014, it had been identified in 29 of the contiguous states. Incidence has been greatest in the hog dense states and also Oklahoma and Kansas, as shown in Figure 1. Data are number of positives based on sample genetic tests, taken from National Animal Health Laboratory Network (NAHLN), as reported in *https://www.aasv.org/pedv/PEDv_weekly_report_140326.pdf*.

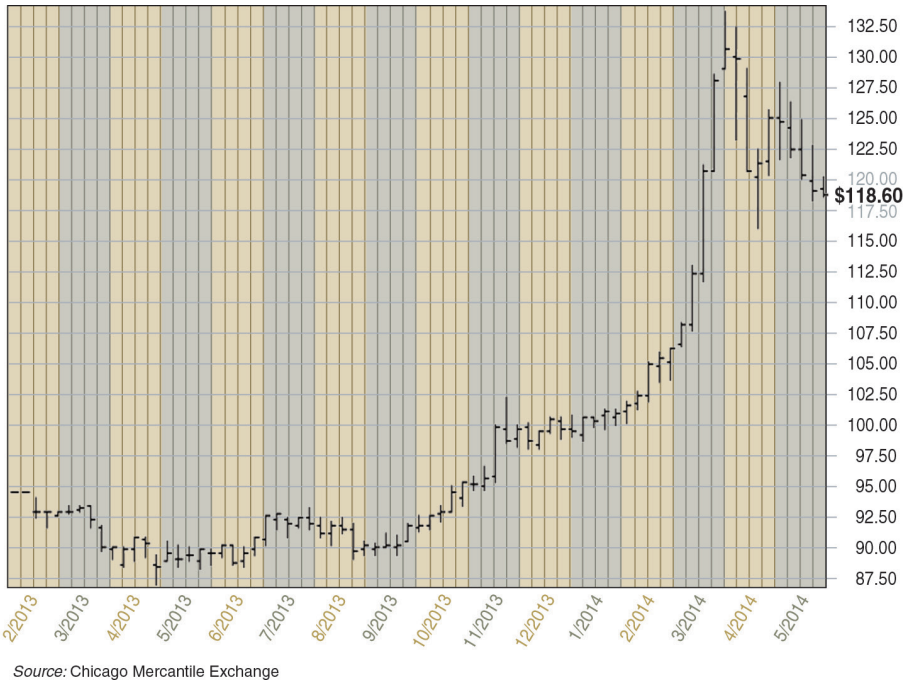
Spread primarily through feces, PEDv induces watery diarrhea, vomiting, and dehydration. The disease, which is not believed to present food safety or zoonotic risks, is generally not fatal for weaned pigs, and older pigs typically recover after about a week. A close genetic variant has circulated through European countries for many years, though the strain circulating through North America bears strongest genetic correlation with types found in eastern Asia.

Prospective impacts on hog markets are unclear. In the March 2014 issue of Rabobank AgFocus, Will Sawyer and Pablo Sherwell speculatively projected a 12.5% decline in North American slaughter levels over 2014–2015 when compared with 2013. Futures traders seeking to process supply-side implications have raised June 2014 maturing lean hog futures prices from about $0.90/lb in April 2013 to about $1.20/lb in May 2014 (Figure 2). The June 2015 maturing contract however, was trading around $0.95/lb on May 20. Figure 3, from CME group home pages, depicts price time series for contracts maturing in June 2014 and June 2015.



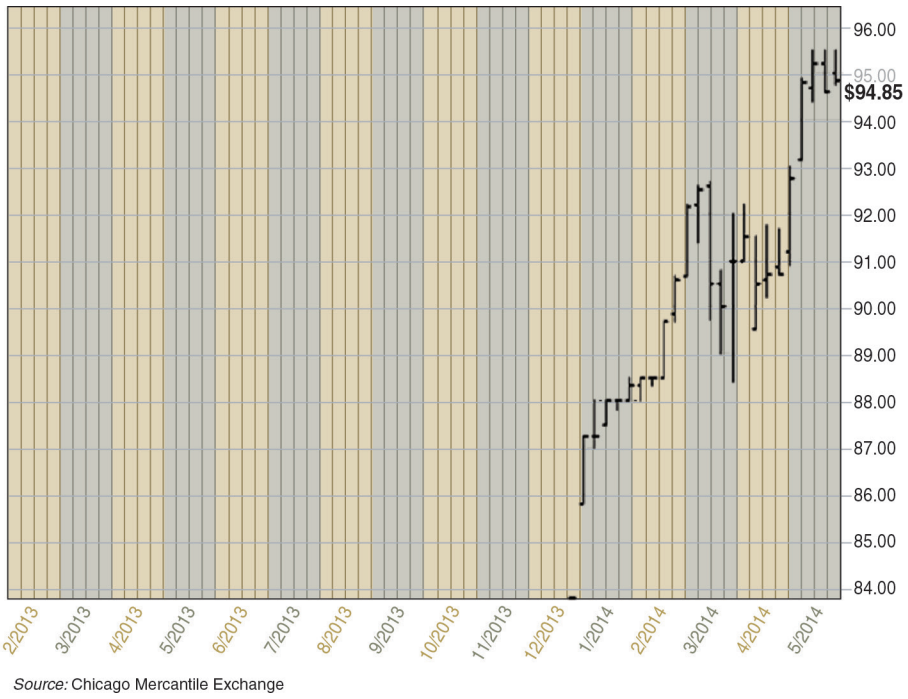
Source: National Animal Health Laboratory Network (NAHLN)

Figure 1. Porcine Epidemic Diarrhea Virus positive tests, May 2014.



Source: Chicago Mercantile Exchange

Figure 2. Weekly Lean Hog Futures Prices on Chicago Mercantile Exchange: June 2014 maturing contract since February 2013.



Source: Chicago Mercantile Exchange

Figure 3. Weekly Lean Hog Futures Prices on Chicago Mercantile Exchange: June 2015 maturing contract since first trading in December 2013.

The purpose of this article is to reflect on two matters: discussion of pertinent public and private biosecurity infrastructure; and likely market adaptation to the disease shock.

Biosecurity

As fecal transmission appears to be the principal mode of transmission, infection will involve physical movement of an infected animal or objects contaminated. Investigations to this point suggest that the virus can survive outside a host for sufficient time to infect through contaminated assets. Although regulations are in place at US points of entry that screen imported livestock, resources allocated to do this are small. The government is also involved in seeking to identify animal disease risks from abroad, and sometimes assisting foreign governments when managing these risks. The PEDv outbreak has been tracked by NAHLN, while state governments are involved in interstate movement controls, educational outreach to growers, and a variety of other endeavors. In April 2014 the USDA declared its intention to mandate reporting of infected herds and institute a national control program.

The final defense is on-farm. Standard biosecurity measures apply, ones that most farms already seek to follow and that also apply for preventing Porcine Reproductive & Respiratory Syndrome virus entry. United States hog production has been organized around longer-term contractual relations for many years. Gilts for the breeding herd and feeder pigs are generally not traded in open markets.

Record keeping, perimeter security, and other biosecurity investments entail large fixed-cost components that involve lower unit costs when applied to larger production units. A reflex response to learning about a disease that spreads rapidly through a production barn may be to wonder why large confined animal facility owners are willing to risk so much to a biosecurity failure. However, fixed-cost considerations suggest that the longer-run response to events such as these is likely to expand both production facilities and resources intent on keeping the disease out.

Market Adaptation

Table 1 shows pigs per litter by herd size since 2000. Data are from the Quarterly Hogs and Pigs Report as issued by the USDA.

The table reveals two points. First, when compared with smaller units, larger sow units perform markedly better by this productivity measure and also appear to have improved at a faster rate over time. Secondly, so far as one can rely on these data, PEDv has set back productivity growth in this measure by about five years. The impact has been uniform across scale of operation.

Table 2 provides data on annual slaughter weight for federally inspected cattle steers and hogs. Data are from USDA NASS Livestock Summary Annual Summary reports.

For both species, dressed slaughter weight has increased by 9%–10% over 1998–2013. Many factors have likely contributed to this change in marketing weight, including genetic improvements, changes in overall feed prices and relative changes in feed price components.

Among possible slaughter weight determinants, we focus on the effects of litter size. Two ways of meeting demand are to increase species breeding herd and to grow animals out to a heavier weight. Biological time lags preclude the former in the short run. Short-run adjustments to meet an increase in demand will entail more intensive feeding to fatten at higher marginal cost. Longer-run, after a year or so for hogs, an expanded breeding herd can also meet demand so that growers will equate the marginal cost of meat due to an increase in breeding herd

Table 1. Pigs per Litter by Sow Herd Size of Operation, three months ending February 2000 through three months ending February 2014.

3 months ending Feb.	500-999	1,000-1,999	2,000-4,999	≥ 5,000
2000	8.2	8.5	8.7	8.9
2001	8.2	8.5	8.7	8.9
2002	8.3	8.6	8.7	8.9
2003	8.2	8.7	8.8	8.9
2004	8.2	8.6	8.7	9.0
2005	8.3	8.8	8.9	9.0
2006	8.3	8.8	9.0	9.1
2007	8.4	8.8	9.0	9.2
2008	8.4	8.8	9.2	9.3
2009	8.4	9.0	9.4	9.5
2010	8.5	9.2	9.6	9.7
2011	8.8	9.3	9.7	9.9
2012	8.8	9.2	9.8	10.0
2013	8.9	9.4	9.9	10.1
2014	8.5	8.9	9.5	9.6

Table 2. Annual Average Dressed Slaughter weight in pounds for Steers and Hogs.

Year	Steers	Hogs	Year	Steers	Hogs
1998	789	189	2006	833	202
1999	793	191	2007	830	202
2000	798	194	2008	838	201
2001	798	197	2009	847	203
2002	823	197	2010	835	204
2003	803	199	2011	841	206
2004	806	199	2012	859	206
2005	817	201	2013	863	207

maintenance costs with the marginal cost of meat due to an increase in feedlot activities. A comparison of Figures 2 and 3 suggests that growers expect longer-run supply adjustments. In the shorter-run lean hog prices were at $1.20/lb in May, but futures prices for a year ahead are $0.95/lb. These differential price responses could reflect anticipated solution or adaptation to PEDv infection and/or anticipated sow herd expansion. The March, 2014 Quarterly Hogs and Pigs Report has revealed a three percent expansion in December-February sow herd numbers over the prior year.

One way to view a reduction in litter size is as an increase in the fixed cost of breeding for any given slaughtered animal. Hog production is a competitive business with free entry so the long run unit cost of producing meat should equal the unit price received. All else equal, as fixed costs increase growers will seek to spread these costs over greater output per animal. Data in Tables 1 and 2 show that, likely for reasons other than litter size, the trend has been toward heavier slaughter weights. The reasoning above suggests that this trend may strengthen over the near future, and especially so if PEDv continues to affect litter size. ■

Ask an Ag Economist

What percentage of Iowa's current row-crop farmer prosperity is the result of row-crop agriculture being completely unregulated in terms of water pollution, and therefore able to externalize water pollution costs? Installing new conventional pattern tiling, for example, raises crop yields but sends more polluted water into the drainage outlet (usually a river or lake). The farmer profits from the increased yield but pays nothing for the increased water pollution, which impacts society at large, since most rivers and lakes are public. Has any research been done on this question?

THE WRITER OF THIS question understands economics and the market failure associated with externalities very well. Thank you for such an informed and interesting question! The writer is quite correct that the fact that agriculture generates an externality (nutrient pollution) that is not priced or regulated creates an incentive for excessive nutrient runoff. Research on this question suggests that the increased price of corn associated with biofuels policy and crop shortages leads to increased planting of corn acreage, in turn resulting in increased nutrient runoff. Some research has gone as far as linking these effects with an increase in the size of the dead zone in the Gulf of Mexico.

However, the writer asks a deeper and more nuanced question: How much of farmer prosperity can be attributed directly to this unregulated externality? This is more difficult to answer, and depends on several factors related to how much of the cost associated with controlling nutrients would be passed on to consumers in the form of higher corn prices. This, in turn, depends on details of the regulation and the responsiveness of the demand for corn to price increases (the elasticity). A key detail of the regulation would be its breadth of coverage. For example, if Iowa farmers in only one county were subject to such a regulation, those farmers would not be able to pass the higher production costs on since they would be competing primarily with farmers who did not face regulation. In contrast, a nationwide regulation that raised all costs uniformly would be most likely to result in higher corn prices to cover these costs. In the latter case, farm profits may not be much affected by addressing the externality, but the costs would instead be paid by end consumers. ■

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The "Ask an Ag Economist" segment is where we invite readers to submit questions to us. We will periodically choose questions of general interest to respond to in future issues.

Questions can be submitted to us through our web site *(http://www.card.iastate.edu/ag_policy_review/ask_an_economist/).*

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