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Two Indianas – A Story of Disparate Growth and Opportunity

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The American Dream, to have a better life than those who came before us, is possible because of opportunity. A favorable juncture of circumstances,* opportunity can be viewed economically as a combination of employment, income, population, and education. More jobs in a location creates a situation in which there are more opportunities to find a suitable match between employer and employee. Larger incomes allow parents to provide better living environments and educational opportunities for their children. Larger populations allow for more specialized jobs and the growth of cultural activity and diversity. More education results in critical thinking, better employability, and higher income.

Urban and rural America offer very different combinations of these aspects of opportunity and each has, at different points in history, been considered more favorable than the other. More recently, it has been noted that economic growth and opportunity has been concentrated in urban areas.

For Indiana, like the rest of the nation, with a combination of urban and rural areas, opportunity varies throughout the state. This article looks at opportunity in Indiana from the perspective of 2003 to 2008 growth. It discusses whether community influences individuals opportunity.

Indiana's Urban and Rural Character

The US Census Bureau constructs geographic classifications based on population density, economic connections, and spatial patterns. A county's classification as part of a Metropolitan Statistical Area depends on population as well as having "a high degree of economic and social interaction" with a core urban area.** In this article, Indiana's 92 counties are divided into urban and rural groups according to whether or not they are included in a 2000 Census Metropolitan Statistical Area. This results in 46 urban counties and 46 rural counties. Figure 1 below shows the location of urban and rural counties.

Urban counties exist in six distinct clusters that are fairly evenly distributed throughout the state, and each is surrounded by a "buffer" of rural counties. These six clusters are around the cities of East Chicago/Gary/South Bend, Fort Wayne, Indianapolis/Terra Haute/Bloomington, Cincinnati, Louisville, and Evansville. The following look at the aspects of opportunity in Indiana divides the state's counties into two groups, urban counties and rural counties, to obtain a general comparison of employment, income, population, and education between urban and rural communities.***

Aspects of Opportunity in Indiana

Employment

In 2008, 2.3 million employees worked in urban counties, and 525

** Merriam-Webster's Online Dictionary. <http://www.merriam-webster.com/dictionary/opportunity>*

*** United States Census Bureau. American FactFinder Glossary. <http://factfinder.census.gov/home/en/epss/glossary_m.html>*

**** Data were obtained from the US Census Bureau's population estimates program (population), the US Census Bureau's small area estimates branch (poverty), the US Bureau of Labor Statistics' Quarterly Census of Employment and Wages (income and employment), and the Indiana Department of Education (education, from StatsIndiana).*

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thousand employees worked in rural counties. This totals to slightly more than 2.8 million people employed in Indiana that year. From these figures, the share of employees in urban counties was 81 percent, while 19 percent of those employed in Indiana worked in rural counties.

Between 2003 and 2008, urban counties experienced a 1.3 percent growth in employment, while rural counties experienced a 2.2 percent loss of employment. Urban counties also had a larger variation in employment change. The largest negative change in employment, - 27 percent (Elkhart), and the largest positive change in employment, 34 percent (Hendricks), were in urban counties. Additionally, 10 urban counties had an employment change (positive or negative) greater than 10 percent, whereas only four rural counties experienced employment change over 10 percent. The largest grouping of these counties with large changes in employment is around Marion County (Indianapolis).

Income

Total wages and salaries, measured by employers' location,**** were a little over $107 billion for Indiana in 2008. Those working in urban counties earned almost $90 billion (84%), and rural county employees earned $17 billion (16%) that year. While both urban and rural counties experienced positive income growth from 2003 to 2008, income growth from wages and salaries was almost twice as large in urban counties (18.5%) than in rural counties (9.4%). Only nine Indiana counties experienced a loss of wages, three urban and six rural. Rural changes in wages ranged from -31 percent (Warren) to 44 percent (Orange). Urban changes were between - 9 percent (Madison) and 88 percent (Newton). The average median income for urban counties was $44,982 in 2003, while rural counties had an average median income of $39,766. Using these values as a base, suggests income in urban areas was 11 percent larger and is growing faster than in rural areas.

Wages are not the only important part of community income. The proportion of the population that lives in poverty is also important. While the proportion of the population that lives in poverty was approximately the same in urban and rural counties in 2008 (13% and 12%, respectively), the actual number of people living in poverty in urban counties, 630,609, was greater than in rural counties (168,958). If urban job growth and income growth continue to outpace that in rural communities, poverty may become a bigger rural issue.

Population

In 2008, Indiana's estimated total population was 6,376,792 residents. This breaks down to 4,989,373 people (78%) living in urban counties and 1,387,419 people (22%) living in rural counties. Urban areas experienced a 4.2 percent growth in population between 2003 and 2008. There was almost no change in population in rural areas (- 0.3%). Once again, urban areas experienced a much larger variation in population growth (between -3.9% in Brown and 22.8% in Hamilton), but a rural county, Blackford (- 4.6%), experienced the greatest loss in population (Figure 2).

Clusters of moderate growth occurred in Northern Indiana and along the border with Kentucky, while a cluster of strong growth occurred in Central Indiana. Additionally, according to the 2008 population estimates by the US Census Bureau depicted in Figure 3, Northern and Central Indiana had the largest populations. Taking into account the population bases and positive growth in urban areas, it makes sense that 78 percent of Indiana's population was living in urban counties in 2008.

Education

When high school graduates intend to advance their education, it suggests they have both the ability and drive to further their possibilities. Indiana had 63,359 graduates in 2007, and 52,598 (83%) of those intended to move on to further education. When observing student behavior separately in urban and rural counties, the percent of high school graduates intending to go on to higher education was high in both. Despite the fact that 84 percent of high school graduates (40,890) in urban areas intended to go on to further education and only 79 percent of rural high school graduates (11,708) intended to do the same, some rural counties had high rates of intended continued education, such as Union County with a 93 percent rate of furthering education. It is important to note that this is voluntary information and does not take into account those who dropped out of high school.

Observing the absolute number of graduates in urban areas (48,453) and in rural areas (14,906), there

***** "Frequently Asked Questions." United States Bureau of Labor Statistics. Quarterly Census of Employment and Wages. 15 Feb 2008. <http://www.bls.gov/cew/cewfaq.htm>.*

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Figure 1. Urban and Rural Indiana Counties, 2008

Figure 2. Population Change in Indiana Counties, 2003-2008

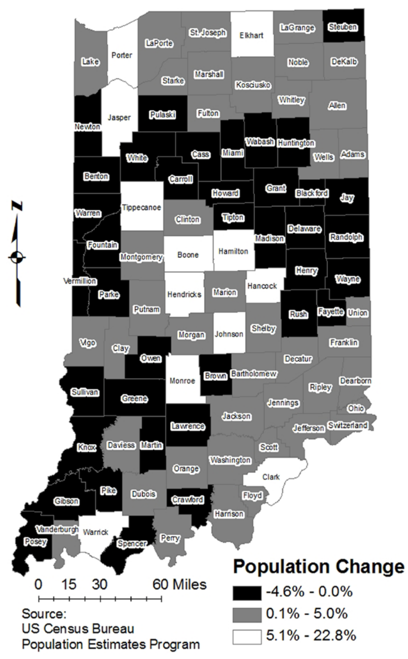
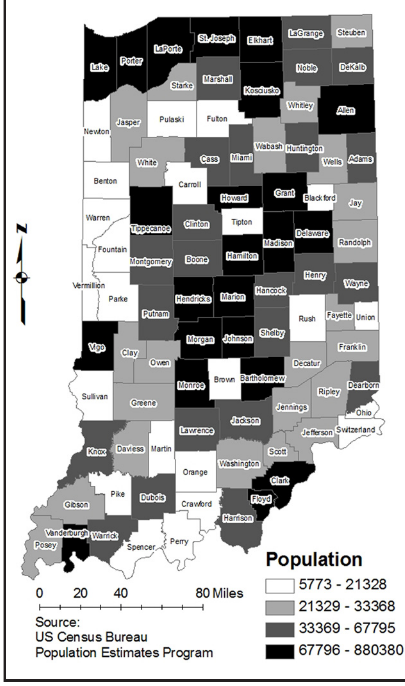


Figure 3. Population of Indiana Counties, 2008



were three times more graduates from urban counties than from rural counties in 2007. This fits with the fact that the majority of the population in Indiana lives in urban counties.

Conclusion

There are numerous characteristics of communities associated with opportunity. Employment, income, and population growth all positively influence the opportunity within a community. Large numbers of high school graduates advancing to higher degrees indicates individuals seeking opportunities. Communities desiring to attract individuals with higher education levels must have jobs for those earning post secondary degrees. If communities do not have jobs, these degree earners will seek them elsewhere.

Looking at these four aspects of opportunity, urban counties had larger growth and numbers than rural counties. This suggests that opportunity and opportunity growth are greater in urban areas. If the trend of positive urban job growth and negative rural job growth continues, rural areas might experience difficulty in attracting new residents and retaining their current workforce. While some people may commute from rural areas to nearby urban areas, the trend of jobs shifting from rural to urban areas would suggest continuous urbanization of the state's population. Interpreting the data this way indicates that there may be two Indianas – one Indiana where a large number of opportunities exist and grow, and another Indiana where there are fewer opportunities and less opportunity for growth.

The Economics of Using Distiller Grains in Small-Scale Beef Operations in Indiana

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The expansion of corn-based biofuels has created an increase in the supply of distiller grain by-products, especially in Indiana and the Eastern Corn Belt. Distiller grains can be used as a corn substitute and are produced in two primary forms, wet distiller grain with solubles (WDGS) or dried distiller grain with solubles (DDGS).

Because of the energy-intensive drying process needed to convert

WDGS to DDGS, WDGS are a cheaper feed source, per dry unit, for producers. Unfortunately, WDGS are especially prone to spoilage due to their high moisture content. The shelf life has been estimated to be as short as a week in the summer months.

For small-scale producers to use WDGS, they would likely need to get partial loads of the WDGS product throughout the feeding season or somehow store it. Partial loads are possible, but would ultimately depend on the relationship with the WDGS supplier and hauler. Because of the high density of WDGS, storing them by themselves in an upright or bag silo is not possible as it would exceed the structural capacity of the storage facility. A possible solution is co-ensiling WDGS with silage.

Ensiling WDGS with silage requires mixing the silage and WDGS products and storing them together. The oxygen–reduced environment of the silage system discourages WDGS spoilage, and all the WDGS the producer is expected to use for the year would be hauled at the same time, so any additional cost for partial loads would be mitigated. In addition, the density of co-ensilage allows for storage in existing silage storage facilities.

Using either form of distiller grains in the feed rations is biologically feasible but poses a different set of economic implications, especially for small-scale producers who face greater risk of spoilage when using WDGS. The objective of this work is to report on different distiller grain feeding strategies for small-scale beef producers in Indiana.

Methods

Based on the biological performance observed and published on small-scale beef producers in Indiana in Arias, et al. 2008 and Arias, et al. 2009, partial budgets were created to reflect the economic impact of using the different forms of distiller grains. For each the two enterprises, bred heifer and finishing steer feeding, four different feeding trials were evaluated, DDGS, WDGS mixed at feeding, WDGS co-ensiled at silage harvest, and a control not using distiller grains. The partial budgets for each ration reflect the changes in costs from the control. Changes in costs included change in the value of production, changes in feed cost, changes in storage cost, product hauling cost, and cost associated with the change in manure value.

Feed Costs: Corn silage price was estimated at $34.10 per ton, or $5 plus 7.5 times the per bushel price of corn, as suggested by Ohio State University silage production budgets (Ward, 2008). Historic prices and value estimators were not available for haycrop silage and alfalfa silage. These values were assumed to be $35 per ton and $45 per ton respectively based on an estimated equivalent to corn silage. Mineral and ration supplements were valued based on Purdue feed mill prices in June 2010, and beef cattle mineral prices were assumed to be $0.84 per pound. USDA's National Agricultural Statistics Services (NASS) database was used to collect average prices for the remaining feedstuffs from 2007-2009, including an average corn price of $3.88/bu and soybean meal price of $290/ton.

Distiller grain prices were gathered from weekly Eastern Cornbelt Ethanol Plant Reports published by the USDA's Agricultural Marketing Service. Monthly averages for 2007-2009 were used to match the timing of the distiller grain purchases. Some seasonality was found to exist in distiller grains prices, and producers could realize lower cost WDGS in August and September. This timing is ideal for the co-ensiling feeding method since it is when the majority of corn silage is harvested. A conversation with a local ethanol plant provided a distiller grains transportation quote at $10/ton for 40 miles.

Storage and Mixing: Costs were based on tractor fuel consumption and operating capacities figured from American Society of Agricultural Engineers Standards (ASAE) for machinery management ("Agricultural Machinery Management," 2001; "Agricultural Machinery Management Data," 2009). Silage and co-ensilage storage was assumed to be in AgBags (bag silos). Area custom rates were found to be $1,100 per bag for the AgBag based on conversations with dealers and includes materials and machine rental. It was assumed that dry matter storage capacity of co-ensiled products was 50% higher than silage alone because of changes in density. For these costs, only additional operating and variable costs were considered.

A critical assumption is that no logistical bottlenecks were created by the co-ensiling process. Specifically, the mixing process was assumed to not interfere with the silage harvesting or hauling processes. Second, three tractors were used, and two operators were required. The control of a normal AgBag operation required only one tractor and one operator. For the co-ensiling process, the first tractor is a front end loader. Navarro, et al. 2010 found that the majority of small-scale farmers in Indiana have either a front-end loader or skid steer. The second tractor was used to power the total-mixed ration (TMR) mixer, and a third tractor was used for the AgBagger. The labor assumption of two l aborers was for one person to operate the front end loader and TMR mixer while the second operator runs the AgBagger. Additional labor was assumed at a rate of $10 per hour and fuel costs were estimated at $2.83 per gallon based the average of fuel prices in Indiana for 2007-2009, as reported in the USDA's NASS database.

Manure: Changes in the value of manure produced and the cost of manure disposal were also considered because feeding DDGS to livestock can result in changes to the manure nutrient profile. The nutrient profiles of the rations were estimated based on the feed intake and adjusted for animal maintenance and production needs using ASAE publication D384. 2 ("Manure Production and Characteristics," 2005). The difference between nutrient intake from the feed and the animal's nutrient use was adjusted to reflect nutrient availability (Joern, Brad C. and Brichford, Sarah L., 1993; Christenson et al., 1992). Based on 2-year fertility needs for a corn-soybean rotation, Massey's fertilizer application model was used to estimate the changes in application costs. The value of the manure applied was based on local commercial fertilizer prices from Miller et al. (2009).

Interest: As feed cost and feed purchasing schedules vary with the different feed rations, changes in interest cost for inventoried feeds were included. Interest charges were assumed to be 4% (Miller, et al. 2009).

Results-Bred Beef Heifers

The bred heifer analysis is based on the costs of feeding 50 head through the winter, 210 days from October 1st to May 1st and based on the results published in Arias, et al. 2008. From the study, the control diet was corn silage and soybean meal based. The test diets were a corn silage and WDGS ration co-ensiled at a dry matter ratio of 3:1 (corn silage: WDGS) (Co-Ensiled), corn silage and DDGS ration mixed at a dry matter ratio of 3:1 (corn silage: DDGS) at feeding (CS+DDGS), and a corn silage and WDGS ration mixed at a dry matter ratio of 3:1 (corn silage: WDGS) at feeding (CS+WDGS). Diets were also supplemented with a mineral premix added at feeding time. The diets were all formulated to be isocaloric and isonitrogneous to meet the appropriate published national research council (NRC) requirements. It should be noted that the performance trial was for only 62 days, but our economic analysis has been expanded to 210 days, a better representation of what farmers are likely to experience.

Table 1 shows the partial budget for the operation and the estimated changes in revenue, cost, and net income if the producer changed to one of the rations containing distiller grains from a base ration that contained no distiller product.

From the partial budget analysis, it is clear that a producer would have the greatest estimated net income increase using the CS+DDGS ration, $1,737. The CS+WDGS resulted in a slight change to the operation's net income, $-37. However, the co-ensiled ration produced a negative change in net income of $-950.

Feed cost for the CS+DDGS diet is the biggest reason the largest positive change in net income. This is because DDGS replace more corn silage in the ration than WDGS. It should be noted that this ration had the lowest daily dry matter intake of the rations evaluated, 15. 41lbs/day compared to 17.26 on the control, 17.73 for co-ensiled, and 17.95 for WDGS.

The negative change in manure value in the CS+DDGS diet was a function of a decrease in the nitrogen levels when compared to the control diet. Each of the diets had higher phosphorus levels and lower potassium levels than the control. The slight change in manure application cost is from a change in the application rates, which affected the number of acres onto which manure was applied.

For the results presented in Table 1, distiller grain transportation costs were assumed to be $10/ton, based on a quote received June 2010 from an Indiana ethanol plant. This quote is 100% variable and does not have a fixed cost, or additional fee, to receive delivery of a partial load of distiller grains. If we assume that distiller grain transportation costs are not completely variable, but that 80% of the total cost of a full

Table 1. Partial budget reflecting changes from the control diet in bred beef heifer trials.

Feeding Bred Heifers
Partial budget for feeding 50 bred heifers from October 1st to May 1st.

	Change from control		
	Co-Ensiled	**CS+WDGS**	**CS+DDGS**
Change in Revenue			
Change in the value of manure production	$255	$133	$(214)
Total change in revenue	*$255*	*$133*	*$(214)*
Change in direct costs			
Change in cost of feed			
Corn Silage	$(1,075)	$(997)	$(1,877)
Soybean Meal	$(3,012)	$(3,012)	$(3,012)
DDGS	$-	$-	$2,941
WDGS	$3,246	$3,349	$-
Mineral premix	$251	$291	$(172)
Additional DM loss from co-ensiling (5%)	$956		
Total change in feed costs	$367	$(368)	$(2,120)
Cost of hauling distillers grain	$531	$537	$220
Change in storage and handling cost			
Additional storage costs (bag)	$-	$-	$-
Additional handling costs			
Bagging tractors operating costs	$7	$(6)	$(11)
Mixing tractor operating costs	$127	$-	$-
Loader tractor operating costs	$62	$-	$-
Additional Labor	$78	$(8)	$(15)
Total change in storage and handling costs	$274	$(14)	$(26)
Change in manure spreading costs	$34	$17	$(25)
Total change in direct costs	$1,205	$172	$(1,951)
Change in net income after direct costs	*$(950)*	*$(39)*	*$1,737*
Change in indirect costs			
Additional interest costs on stored feed	$0	$(3)	$(0)
Change in net income after direct and indirect costs	*$(950)*	*$(37)*	*$1,737*

load are variable, we find that the CS+WDGS ration is adversely affected, showing a new change in net income of $829. The co-ensiled and CS+DDGS diets are only slightly affected by this because when hauling all distiller grain in at one time and have only one partial truck load. If 76% of a full load's total cost were to be variable, the co-ensiled and CS+WDGS ration would be indifferent, with a new negative change of net income of $-985 for both.

It was assumed that the economic value of the bred heifers after feeding is based on factors outside the scope of this analysis and not affected by the observed variations in body weight. For this reason, no attempt was made to capture a dollar value for changes in animal performance across the four rations.

Results-Finishing Steers

The finishing steers study consisted of four test diets (Arias, et al. 2009). A ration based on corn silage, cracked corn, and soybean meal was used for a control to illustrate the base of a small operation not currently using distiller grains products. The other rations tested were a haycrop silage and WDGS ration co-ensiled at a dry matter ratio of 3:1 (haycrop silage: WDGS) (Co-Ensiled), a haycrop silage and WDGS ration mixed at a dry matter ratio of 1:2. 33 (haycrop silage: WDGS) that was mixed at feeding (H+WDGS), and a haycrop silage and DDGS ration mixed at a dry matter ration of 1:2.30 (haycrop silage: WDGS) that was mixed at feeding H+DDGS). All the diets contained cracked corn and were isocaloric and isonitogenous, and meet the appropriate NRC requirements.

The steers were placed on feed at 723 lbs. and fed until harvest, which was determined when the 12th rib's fat depth was 0.42 +/- 0. 11 inches. Because of this, the number of days the finishing steers on feed was different for each of the feed trials. It should be noted that this economic analysis did not consider an opportunity cost for the feeding pens when cattle were kept for longer days on feed. The underlying assumption is that only one batch of cattle are fed in the facility per year and that during the intervening days between batches the facility sits idle.

Table 2 is the partial budget showing the economic changes the distiller grains diets have on net income. The partial budget is based on the feeding of 50 head.

In all three test rations, there appears to be an economic incentive to use distiller grains. The largest estimated impact on net income is for a switch to the haycrop and distiller grain rations. This is primarily caused by the haycrop and distillers being cheaper sources of feed and the greater degree of substitution for cracked corn.

The change in revenue from the sales of animals was based on an average per hundred weight price of beef cattle in Indiana from 2005-2009. Steer values were estimated as $81.08 cwt., based on the USDA NASS database. No meat quality considerations were accounted for in the revenue calculations. The revenue loss in the H+WDGS ration is due solely to the lower final body weight.

Feed cost for the H+WDGS ration is a result of the fewer days on feed and higher feed conversion efficiency.

Table 2. Partial budget reflecting changes from the control diet in finishing steer trials.

Feeding Finishing Steers
Partial Budget for feeding 50 finishing steers to 0.42 inches of 12th rib fat depth

	Change from the control		
	Co-Ensiled	**H+WDGS**	**H+DDGS**
Change in Revenue			
Change in revenue from sale of finished steers (based on final body weights).	$223	$(1,192)	$223
Change in value of manure	$609	$80	$373
Total Change in revenue	*$832*	*$(1,112)*	*$596*
Change in direct cost			
Change in feed costs			
Haylage	$2,007	$664	$817
Corn Silage	$(1,079)	$(1,079)	$(1,079)
Cracked Corn	$(484)	$(3,039)	$(1,533)
Soybean Meal	$(3,351)	$(3,351)	$(3,351)
WDG	$924	$2,189	$-
DDG	$-	$-	$2,700
Additional DM loss for co-ensiling (5%)	$147	$-	$-
Total change in annual feed costs	$(1,837)	$(4,617)	$(2,447)
Cost of hauling distillers grains	$151	$351	$202
Change in storage and handling costs			
Additional storage costs (bag)	$-	$-	$-
Additional handling costs			
Bagging tractor operating cost	$3	$(1)	$(1)
Mixing operating cost	$37	$-	$-
Loader operating cost	$18	$-	$-
Additional Labor	$31	$(4)	$(3)
Total change in storage and handling costs	$88	$(5)	$(4)
Change in manure spreading costs	$81	$17	$49
Total change in direct costs	*$(1,517)*	*$(4,254)*	*$(2,200)*
Change in net income after direct costs	*$2,349*	*$3,142*	*$2,796*
Change in indirect costs			
Additional interest on feed	$1	$2	$28
Change in net income after indirect and direct costs	*$2,347*	*$3,140*	*$2,768*

The steers on this rations consumed less feed than the control and the other two distiller grains rations.

If we consider a fixed cost, or additional fee, to receive a partial load of distiller grains, the H+DDGS and co-ensiled rations are relatively insensitive as they receive their loads at one time with only one partial load. When the variable costs are at 82% of a full load's total cost, producers are indifferent between H+WDGS and H+DDGS with the new change to net income for both at $2,769. Furthermore, when the transportation costs are 61% variable, there is indifference between the co-ensiled and H+WDGS rations with the new change to net income at $2,319.

Conclusion

From the rations evaluated, small-scale producers feeding bred heifers have the greatest opportunity to capture economic benefits of feeding distiller grains with the DDGS ration. Mixing WDGS at feeding resulted in a small negative change in net income, but would become even more negative as the cost of a load of WDGS has a higher fixed cost component. Feeding WDGS in the co-ensiled ration was the least desired feeding option, and producers would be better off feeding the control ration with no distiller grains.

The three rations evaluated for finishing steer all provide economic incentive for the use of distiller grains products. Mixing the WDGS at feeding provided the greatest incentive, but would become less favorable as the cost to haul a load of WDGS has a higher portion of fixed costs. Again, feeding WDGS in the co-ensiled ration is not the favored feeding ration but, in this case, is a more profitable feed ration than the control.

Overall, small-scale beef producers do have economic opportunities to use distiller grains with their bred heifer and finishing steer operations. On-farm retrofitting of equipment could make this co-ensiling process more efficient and lower some of the added handling cost. Finally, producers should carefully evaluate their unique storage, equipment, and feeding systems before switching their beef feeding strategies to include a distiller grains product.

Editor's note: For a full-length version of these results, contact the co-author at dwidmar@purdue.edu

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The Economics of Harvesting Corn Cobs for Energy

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Wallace E. Tyner, Professor and Chris Hurt, Professor

Biomass energy has received much attention in recent years. We now use about one third of the U.S. corn crop for biofuels. More recently, attention has focused on cellulosic resources – energy crops like switchgrass or miscanthus, and corn stover. But the question we explore is the economics of collecting just the corn cobs for energy instead of the stover. What are the costs of harvesting cobs? Will harvesting cobs generate extra returns for farming operations? To help answer the last question, we estimate the per ton payment farmers need to receive for harvesting cobs during the corn harvest.

Corn stover, the non-grain residue left on the field after harvest, has been shown to have significant potential in Indiana as a biofuels feedstock. However, collecting the corn stover and removing the residue from the field may have implications for soil erosion and soil quality. One possible feedstock that would not overly affect organic and nutrient content in the soil is the corn cobs. Little or no work has been done on the economics of harvesting and collecting just the cobs.

The Analysis

Data on cob harvest was obtained from farmers who supplied cobs for Chippewa Valley Ethanol Company in Minnesota during the 2009 corn harvest. Chippewa is one of the few firms collecting and using cobs. We collected the data through two focus group sessions with farmers harvesting cobs and a mailed questionnaire. Based on information on costs and extra time required provided by these farmers, we created a cob harvesting activity that could be added to the Purdue B-21 PC-LP Farm Plan model which is used to select the best crop rotations on each farm. The standard crop choices (corn-corn, corn-soybean, corn-soybean-wheat, etc.) were retained, but new activities were added that included cob harvest. In other words, in the model there was a choice between the normal corn rotations and corn rotations including cob harvest. In that way, we could estimate the relative attractiveness of the added cob harvest over a range of cob prices. The PC-LP model was simulated to reflect the optimum crop rotations for a group of farms. Data for this group came from 55 farms that participated in the 2009 Top Farmer Crop Workshop. These farms together represent about 100,000 acres of corn without any cob harvesting and also have other soybean and wheat acres. The individual farm data was used on a confidential basis.

The cob harvesting activity is a one-pass harvest of corn and cobs and involves pulling a dedicated cob collection wagon behind the combine. At this time, there is only one manufacturer of the wagon and that company only leases the wagons. That lease rate of $28,000 per year represents a large fixed cost.

Cob harvesting involves additional costs beyond the cob wagon. Pulling the wagon requires added fuel and maintenance on the combine. The cobs must be offloaded from the wagon into a truck with a hoist and hauled to the field edge. This will require additional labor and some added costs for fuel and maintenance on the cob truck. These costs were estimated by our Minnesota farmer survey and are included in the analysis.

Clearly, the cob harvest takes more time, and most farmers agree that slowing the corn harvest can be costly. For this reason, we included a cost for the decreased harvest working rate.

Nutrients that are in the cobs were another important cost that was included in the study. During normal corn harvests the phosphorus and potassium in the corn cob would be returned to the soil. When the cobs are harvested for ethanol, farmers face the additional costs for these nutrients that are destined for the ethanol plant and thus not returned to the soil.

Base Case & Interpretation at $100 per Ton

In the preliminary analysis, we found that the results were particularly sensitive to the amount of cobs in the stover, the cost of the cob wagon, and the decreased harvest working rate due to the added cob harvest activity. Thus, sensitivity was done on those variables. The amount of cobs in the overall stover has not been well studied, but the limited literature suggests a range. As a result, we used 20% in the base case. The lease rate for each cob wagon is $28,000 for the entire harvest season. The base case assumes a 10% decrease in the harvest working rate due to the added cob harvest activity. In general, the data came either from the Minnesota farmers or from earlier studies. Table 1 shows the base case of the 55 farms from PC-LP.

From Table 1, the first data column is the standard PC-LP solution without the cob harvest. The acres row is the sum of corn acres for the 55 farms, which is 100,264 acres. This can be thought of as the optimum number of acres these 55 farms would plant to corn if they were maximizing their returns. The columns to the right add cob harvest at different cob prices.

At $40 per ton, no farms participated in the corn plus cob harvest because it was not profitable to do so. As the price for cobs increased, a higher percentage of the corn acres were used for harvesting corn plus cobs. At $100 per ton, 40% of the farms (22 out of 55) and 54% of the corn acres were used for the corn plus cob harvest. At $100 per ton, “Corn plus cob acres” increased to 60,363 acres, which resulted in an overall increase in “Total Corn Acres” to 111,843 acres. Because total corn plus cob acres increased, cobs harvested during the corn harvest also increased. The $100 per ton price increased corn acres by approximately 12%. The net change in the margin induced by cobs at $100 per ton was approximately $23 per acre of corn plus cobs.

With higher cob prices, some soybean and wheat acreage shifted to corn. This was due to the farms receiving a higher payment for their overall corn enterprise while holding soybeans and wheat constant at their original prices. Finally, the higher payment for cobs caused gross margins to increase. At $60 per ton, the gross margin change induced by cobs was estimated at $10 per acre of corn. At $120 per ton, the participating farms’ gross margin change induced by cobs was approximately $37 per acre of corn plus

Table 1. Impacts of Incremental Cob Prices on Corn Acreage and Participating Farmers' Gross Margin (Base Case)

55 farms	Corn Harvest (w/o Cobs)	Corn Harvest w/Cobs ($40/ton)	Corn Harvest w/Cobs ($60/ton)	Corn Harvest w/Cobs ($80/ton)	Corn Harvest w/Cobs ($100/ton)	Corn Harvest w/Cobs ($120/ton)
Farm Participation For Cobs	0	0	3	14	22	22
Total Corn Only Acres	100,264	100,264	96,839	60,074	51,480	49,308
Total Corn + Cob Acres	0	0	4,296	43,560	60,363	65,800
Total Corn Acres	100,264	100,264	101,135	103,634	111,843	115,108
% Corn + Cob Acres	0.0%	0.0%	4.2%	42.0%	54.0%	57.2%
% Change In Corn Acreage	0.0%	0.0%	0.9%	3.4%	11.5%	14.8%
Total Gross Margin	$43,361,364	$43,361,364	$43,404,663	$43,857,706	$44,723,807	$45,766,278
Participating Farms' Gross Margin Change Induced By Cobs ($/acre)	$0	$0	$10	$11	$23	$37

cobs. To calculate this number, we subtract the base case gross revenue of $43,361,364 from the gross revenue at $120 of $45,766,278 to get $2,404,914. We then divide this change by the cob acres (65,800) to get $37.

Having examined the impact of cob price on farm participation and acres harvested for cobs, we are going to assess three factors critical to the economics of cob harvesting:

1) The decreased harvest working rate;

2) A less expensive cob wagon rental at $14,000; and

3) Smaller fraction of cobs in residue.

Decreasing Harvest Working Rate

Harvesting cobs along with the corn slows down the corn harvest. Our base case assumption from the Minnesota farmers was that there was a 10% reduction in the harvest working rate. However, the bottom line for this sensitivity analysis is that the change in the harvest working rate was not a major driver of whether farms harvested cobs during the corn harvest. However, while this result holds for a normal year, it could be very different for years with a very late harvest when slowing harvest by 10% could result in larger field losses due to lodging and non-optimum harvest dates.

Less Expensive Cob Wagon Lease at $14,000

Reducing the lease rate of the cob wagon to $14,000 increased the percentage of corn plus cob acres in the corn enterprise to 38% at $60/ton cobs. At $80 per ton, the $14,000 lease rate resulted in over 50% of total corn acres for the corn plus cob harvest activity. By comparison, in the base case with a $28,000 lease rate, corn plus cob acres did not reach the 50% benchmark until $100 per ton. Clearly, the cob wagon lease rate is a major determinant to the economics of cob harvest.

Different Percentages of Cobs in Residue

Since there is little research on what is the percentages of cobs in corn stover, we examined the impacts if the cob percentage was only 15.7% instead of the 20% in the base case. All other costs associated with the base case did not change. These results are shown in Figure 1. At 15.7% cobs, farms harvested fewer cobs per acre, which made it harder to offset the costs associated with cob harvest. At $100 per ton, the base case reached the 50% benchmark. Meanwhile, the 15.7% case did not reach the 50% benchmark until $120 per ton. This indicated that farms need to receive a higher

Figure 1. Percentage of Corn Plus Cob Acres in Corn Enterprise For the Base Case vs. 15.7% Cobs Case

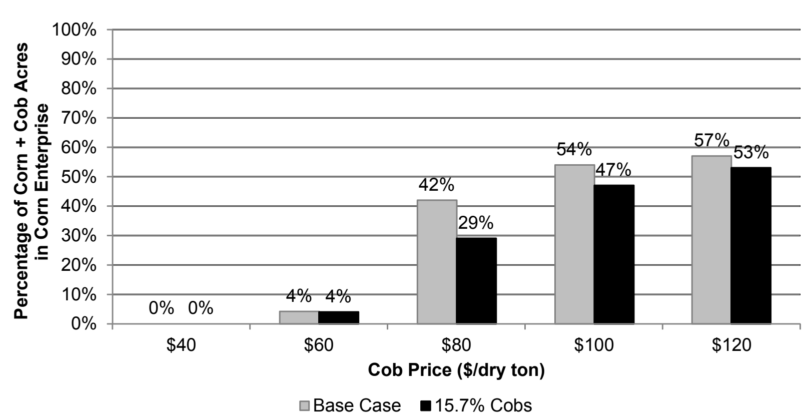
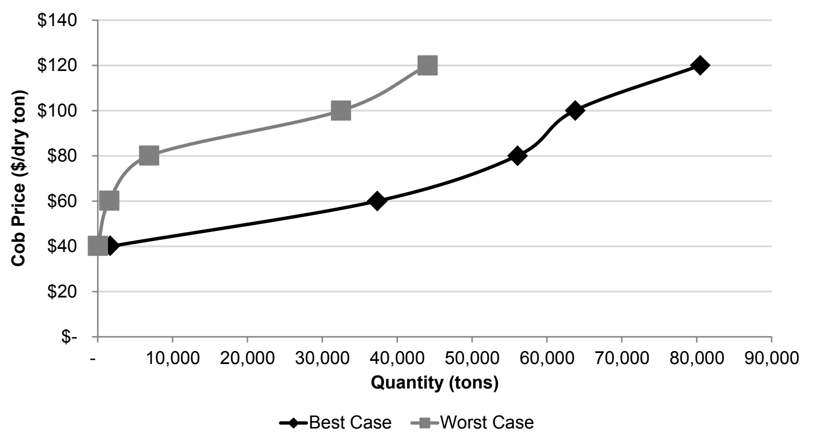


Figure 2. Results Under Best Case and Worst Case



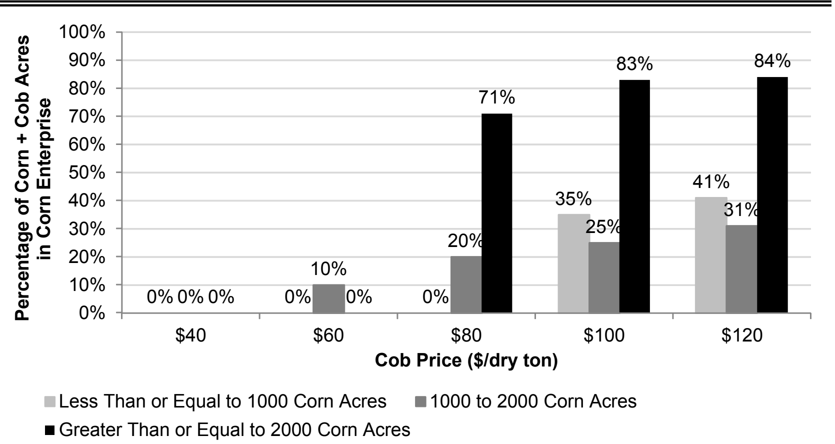
cob price when the fraction of cobs in stover is lower in order to cover all the added costs for cob harvest.

Best Case vs. Worst Case

Since this is largely a first attempt at evaluating the economics of cob harvest, we have examined a "best case" if all the critical parameters are better than expected, and a "worst case" if all parameters are worse than expected. The best case was based on 20% cobs, a $14,000 lease rate, and a 5% decreasing harvest working rate. The worst case used 15.7% cobs, a $28,000 lease rate, and a 15% decreasing harvest working rate. Figure 2 shows the price-quantity relationships of the total tons of cobs harvested between the best case and worst case at various cob prices.

As cob prices increased, the 55 farms supplied more cobs to the market. The best case resulted in considerably more cobs harvested than the worst case at all cob prices. At a $100 per ton cob price, cobs harvested in the best case were about double the worst case. At $120 per ton for the best case, 33 farms harvested approximately 80,000 tons of cobs. This is equivalent to approximately 5.6 million gallons of ethanol production. For the worst case, 21 farms harvested approximately 44,000 tons of cobs. This is equivalent to approximately 3.1 million gallons of ethanol production.

Figure 3. 55 Farm Sample Broken Down Into Three Corn Acreage Categories



Size of Farms for Which Cob Harvesting is Feasible

Are smaller or larger farms more likely to harvest cobs? For this analysis, the 55 farms from the base case were split into three corn acreage categories. There were 14 farms with fewer than or equal to 1000 corn acres, 28 farms between 1000 and 1999 corn acres, and 13 farms with 2000 or more corn acres. Figure 3 shows the cob harvest acres as a percent of total corn acres for the three corn acreage categories by cob price.

Farms that contained 2000 or more corn acres generally had much higher cob harvest as a percent of total corn acres. The 13 farms that contained 2000 corn acres or more were better able to cover the additional costs associated with cob harvest than smaller farms. In fact, all 13 farms with 2000 corn acres or more added a second cob wagon at a total lease rate of $56,000. At $80 per ton received for cobs, the farms with 2000 or more corn acres harvested cobs on 71% of their total corn acres. For the 14 small farms with 1000 corn acres or fewer, only three farms harvested cobs. The three farms that harvested cobs had high expected corn yields of 210 bushels per acre, which resulted in higher cob yields. Smaller farms might still harvest cobs if their yields were quite high.

The cost of harvesting cobs has high fixed cost components, especially for the seasonal lease rate of the cob wagon. With high fixed costs, the costs per unit are lowered by spreading these costs over harvesting large quantities of cobs. The large quantities of cobs can come from either large acreage (large farms) or for some smaller farms with high corn yields per acre.

Impacts of a Corn Yield Shock

How would a surprisingly small yield due to a poor growing year impact cob harvesting costs per ton? A 17% yield shock would increase the costs to harvest cobs by $6 to $9 a ton for a sample farm with cobs at $100 per ton. Table 2 indicates the total per ton cost for cobs for the three decreasing harvest working rates for a sample 686 corn acre farm. The higher costs per ton results because most of the costs are fixed and the 17% yield shock reduces total cob tonnage by roughly the same percentage.

Table 2. Cob Costs per Ton for a 686 Corn Acre Farm With and Without the 17% Yield Shock

	Cost for Harvesting Cobs @ $100/ton Cob Payment ($/ton)	
	No Yield Shock	With 17% Yield Shock
5% Decreasing Working Rate	48	55
10% Decreasing Working Rate	52	60
15% Decreasing Working Rate	54	63

Summary and Conclusions

This study reports on the economic costs and returns for harvesting corn cobs used as a feedstock for cellulosic ethanol production. As such, it is one of the first studies to shed light on important questions such as how can cobs be harvested, what are the costs of doing so, what will the price of cobs need to be in order to encourage cob harvest, and what types of farms will be most likely to harvest cobs.

Perhaps the most important conclusion is that cobs are more expensive to harvest for energy than many had originally thought. Our results suggest that harvesting of cobs in the Midwest would not become attractive unless cob prices approach $100 per ton. In addition, there are costs to store and transport cobs to ethanol plants. Some people viewed cellulosic material as a by-product that had little cost. That clearly is not the case, including the costs of corn cobs examined in this study.

If ethanol plants are unable to pay $100 per dry ton for cobs at the field in the near future, additional incentives would be required to cover the differential payment and make cobs "economic."

It was evident that the cob operation is more attractive for larger farms. Farms containing 2000 or more corn acres were better able to offset the large fixed costs of harvesting cobs, thus reducing per unit costs. For smaller farms, the fixed lease rate of the cob wagon at $28,000 per year was a barrier to entry. The inability to offset the wagon lease rate and the other associated cob costs appears to be challenging for small farms. However, decreasing the rental cost of the wagon to $14,000 allowed for higher participation of small to moderate farms in cob harvest.

Every farm is unique. The results of this analysis demonstrate that the breakeven prices for cobs can differ substantially among farms depending on corn yield, farm size, and other factors. Results are quite sensitive to the cob wagon cost and the fraction of cobs in the stover. However, the major conclusion is that cobs will be more expensive than previously believed – maybe too expensive to be used for energy production unless the public is willing to further subsidize such activities. Another important possibility is that cob harvest technology could evolve into different systems that might lower cob harvest costs.

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Indiana Estate & Family Farm Business Transfer Planning: Individuals, Spouses, Professionals & Family Businesses

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