APRIL 2021

PURDUE AGRICULTURAL ECONOMICS REPORT

2021 Graduate Student Research Issue Contents:

FROM THE EDITORS:

Roman Keeney, Associate Professor of Agricultural Economics
Mario Ortez, Agricultural Economics Ph.D. Candidate

Welcome to our first PAER issue of 2021! We look forward to aggregating the great work from the Ag Econ Department this year and helping to bring it to the PAER readership. A key mission of PAER is to represent the breadth of research in our Department and make it accessible to our readership. We hope that a reader surveying our list of articles comes away with a sense of how robust the department's research profile is – spanning discussion of Indiana's farmland prices to major international policy debates-.

The editors, in pursuit of the PAER mission, opted to make the April issue themed "Graduate Student Research." The Purdue Ag Econ graduate students are a key element in research productivity and intellectual drive. We are proud to be training and collaborating with these beginning researchers that will set the standard for discovery in their disciplines for the next generation. Moreover, calling on this group for PAER submissions provides a great lens for readers around the Indiana and the Midwest to view a snapshot of the graduate students-led intellectual life of our Department.

Our April issue collects six articles that nicely represent the research output of our graduate students. To highlight the ownership and creativity of our graduate student body, the articles presented in this publication were led by a graduate student who in collaboration with Purdue faculty, and in one case an alumnus of our Department, was able to develop a relevant idea into a relevant research article.

PURDUE UNIVERSITY | Agricultural Economics

We lead the April issue with two articles that examine supply (Morissette, Lusk, and Bourquard) and price (Mefford and Mallory) relationships in agriculture and how the economic stressors of COVID are being revealed in these markets. Following the two COVID related articles, we feature a piece that examines how experts form expectations about farmland markets (Fiechter, Brewer, and Kuethe).

The second half of the issue begins with a graduate student contemplating the rote assumptions we tend to make about short run decision-making in agricultural supply (Ortez). This is followed by a study of opinions and willingness to pay for averting a key emerging pollution threat (Moon and Wang). We also feature a case study essay prepared by three graduate students (Ortez, Nguyen, and Neuhofer) that explores productivity and market access for small sugar cane farmers. Finally, we close the issue with an article that summarizes the graduate student research award winners from the Department in 2020 in our three programs (Dr. Travis Atkinson, PhD program; Natalie Loduca, MS program; Cain Thurmond, MS-MBA program).

These last four items in the April issue give insight into the different ways our graduate students engage the research frontier and advance it – developing ideas that are first formed in the classroom, further nurtured with the help of our faculty and finally working together to successfully bring them to completion. Here at Purdue Agricultural Economics Department, we are very excited and very much looking forward to the national and international competitions where these studies will compete.

PURDUE AGRICULTURAL ECONOMICS REPORT

Title:	COVID-19 Disruptions to Indiana Food Supply Chain
Authors:	Kendra Morrissette, Jayson Lusk, Brian Bourquard
Series/Article ID:	PAER-2021-2
Date:	April 22, 2021
Summary:	An analysis of the impact of COVID-19 on Indiana agriculture production through 2020.

Background

The past year has been nothing short of record-setting, not only in the United States, but around the world since the outbreak of the coronavirus. March 2021 began a year of disruption, change, and shifting of not only how we live and operate in our daily lives but how our food is produced, transported, and sold. The coronavirus did not spare any industry, and agriculture is not exception. This paper aims to discover the impact that the coronavirus had on revenues from major commodities in Indiana.

The largest crops produced in Indiana are corn and soy, whose production total over 10 million acres combined. Indiana farmers produced $3.3 billion in corn and nearly $2.5 billion in soybeans in 2019, which in total represents half of Indiana's farm commodity sales. Indiana is home to two large pork processing plants, and as a result, export a significant amount of pork each year. Because pork processors were significantly impacted by the coronavirus, this report investigate the impacts of COVID19 on this industry. Additionally, Indiana is the 2nd largest egg producing state in the country producing 847 million (measured in dozens) eggs in 2020.

Data & Analysis

To determine impacts of COVID-19 on revenues for corn, soybeans, hogs, and eggs, we relied on monthly price and production data supplied by the U.S. Department of Agriculture. In each case, 2019 data were used to extrapolate the quantities and prices that would have been witnessed had COVID-19 not occurred, and these values were compared to the revenues and production values actually witnessed in 2020. The difference between these two values is the estimate of change in revenue or production from COVID. Because not all price changes are a result of COVID, for corn and soy, we calculated a range of economic damage attributed to COVID-19 using three different values: 50%, 75%, and 100%.

Results

Figure 1 shows the estimated monthly economic impact to the corn crop in Indiana due to the coronavirus. There were revenue losses beginning in April 2020 and continuing late into the year; however, a recovery began as 2020 came to an end. The estimated losses to corn production in Indiana from January to December 2020 due to COVID-19 were between $42 and $155 million. A significant driver behind this reduction in corn prices is the decrease in demand for ethanol and corn as animal feed as the stay-at-home orders went in effect throughout the United States forcing consumers to stay home and food service industries to close. A similar analysis was done estimating the impact of COVID-19 on the soybean crop in Indiana; however, March was the only month of 2020 to see a decrease in the price of this commodity.

Revenue losses to the hog industry in Indiana due to COVID-19 are about $21 million from January through December 2020. The estimated monthly losses are shown in Figure 2. The red bars show the months with estimated losses to the industry. April through August show losses to pork production; however, the industry recovered to pre-coronavirus production levels by September 2020.

Estimates show a significant increase in table egg revenue at the beginning of the pandemic followed by a quick price drop off as supply chains adjusted. For the 2020 (as compared to 2019) production of table eggs were higher month over month for the entire year (Figure 3). We see a similar pattern with breaker egg prices (Figure 4) increasing in revenue during March 2020 but dropping back to historic levels in April 2020.

Summary

Overall, there were significant impacts to the agriculture industry in Indiana because of the ongoing pandemic with the largest impacts seen in the corn and hog industry; however, both industries recovered by late summer. Fast adjustments along the food supply chain paired with a recovery in commodity prices, led by an increase in exports to China and adverse weather condition in parts of the Midwest, helped agricultural markets recover by the end of 2020.

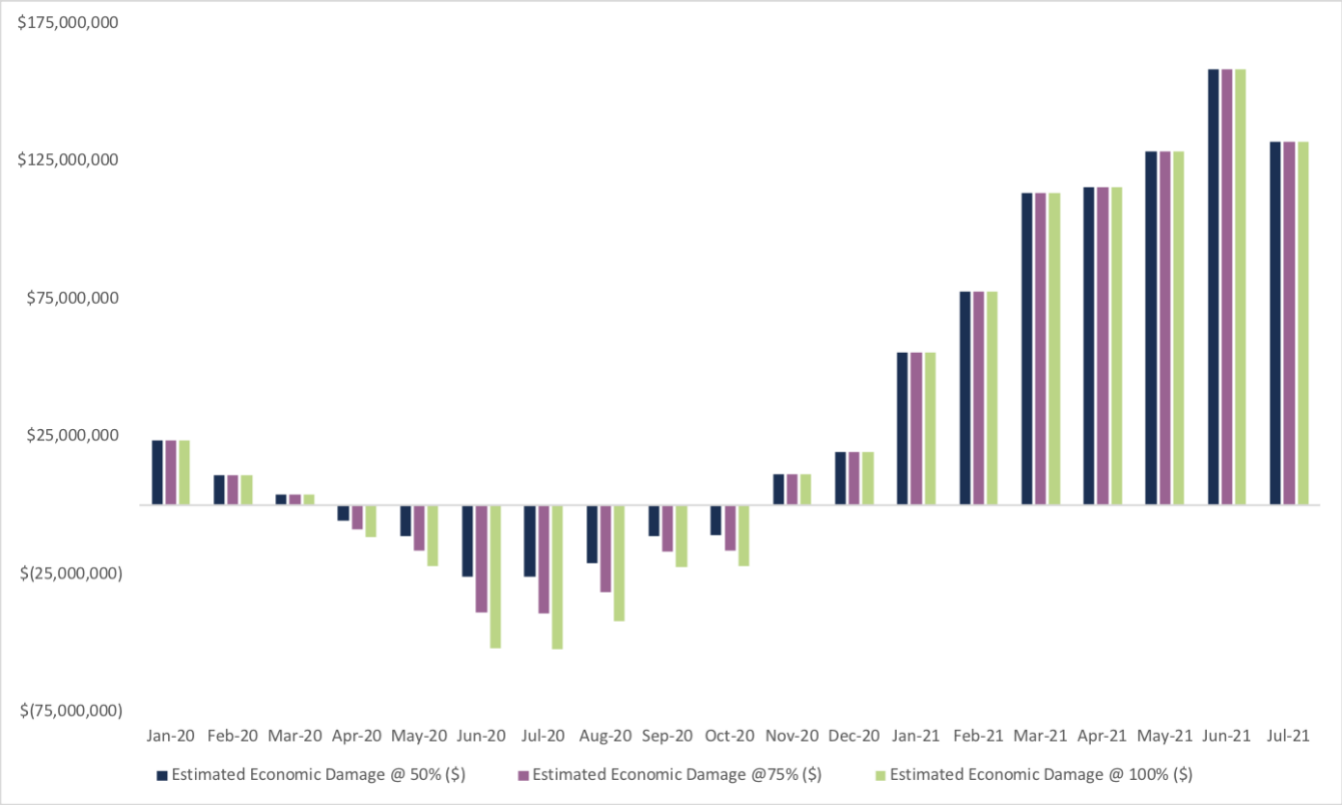


Figure 1: Estimated Monthly Economic Damage to Corn Crop in Indiana Due to COVID-19

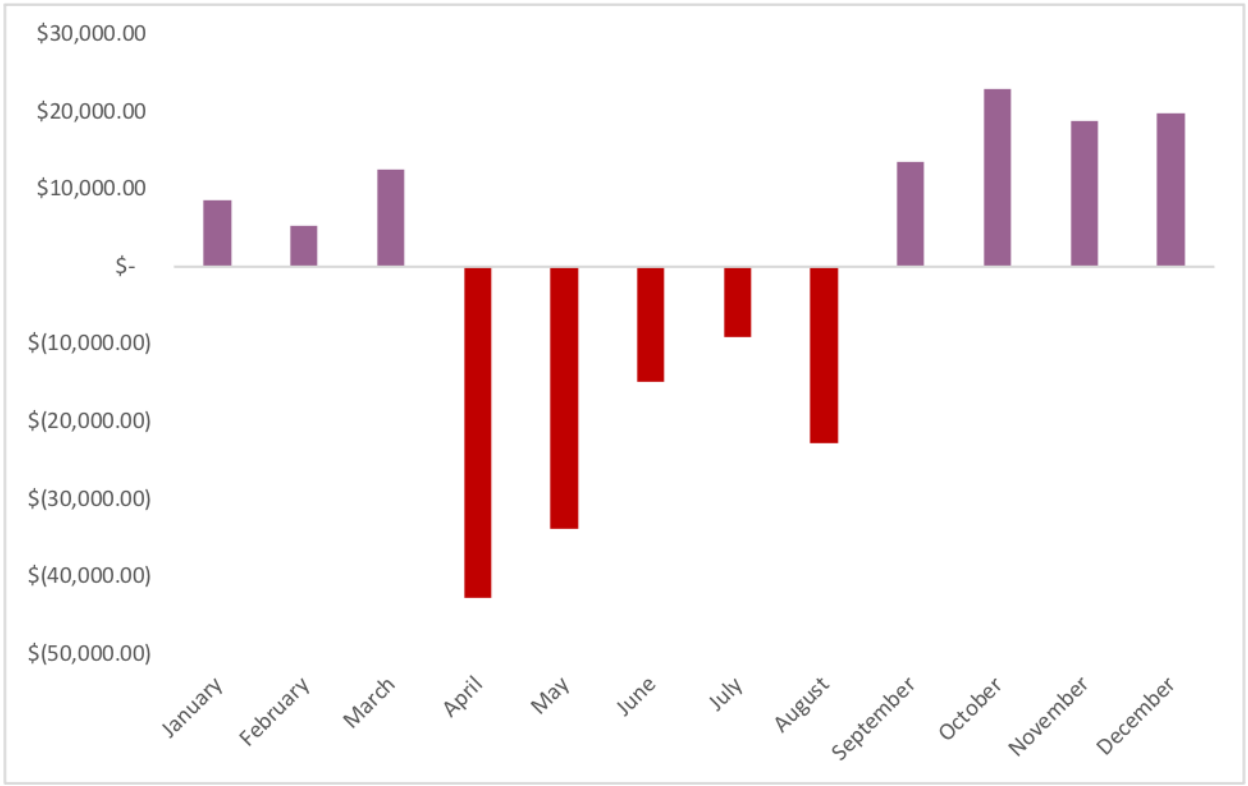


Figure 2: Estimated Loss for Indiana Hog Production Per Month

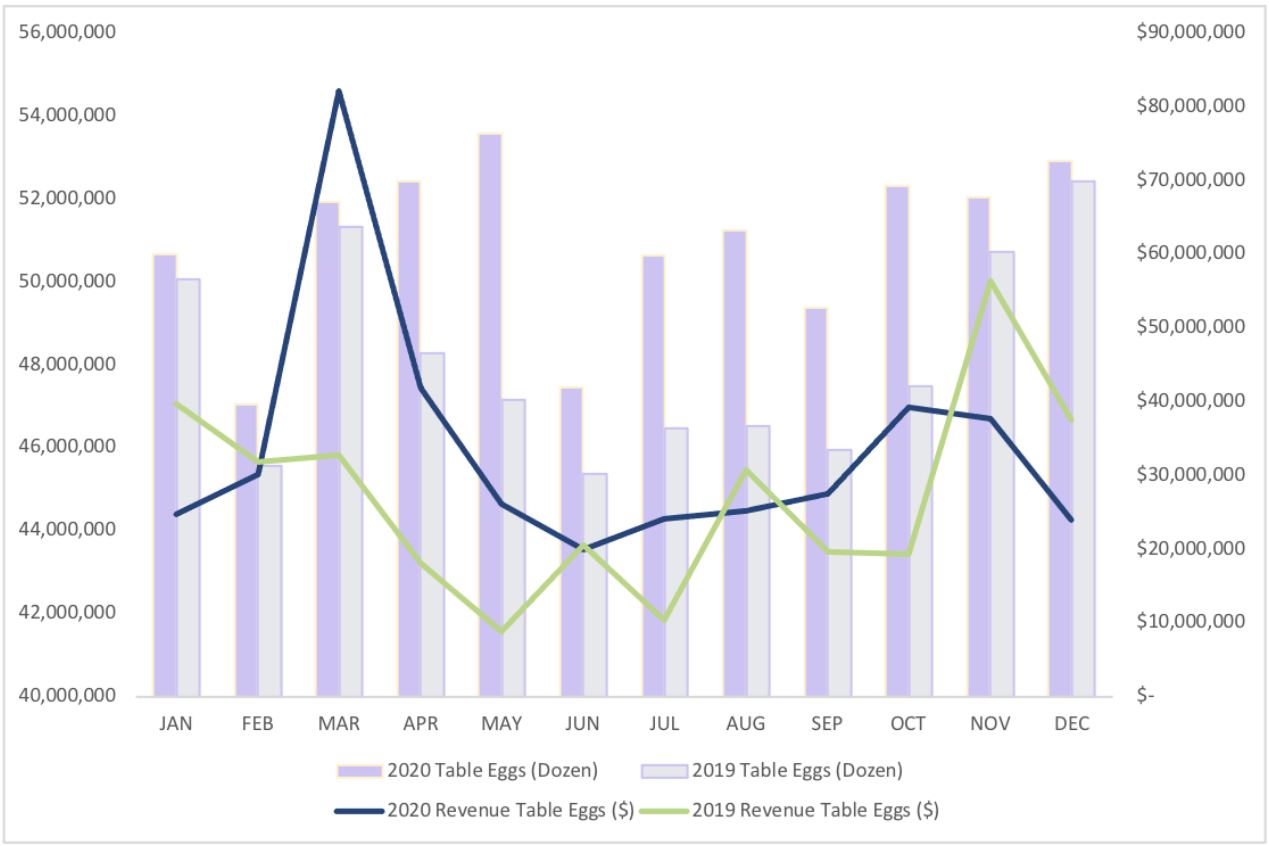


Figure 3: Indiana Table Egg Production and Estimated Revenue Losses

Figure 4: Indiana Breaker Egg Production and Estimated Revenue Losses

PURDUE
AGRICULTURAL ECONOMICS
REPORT

Title:	All Correlations Go to 1 in a Crisis: The Cattle Crush Spread during COVID-19 Crisis
Authors:	Eli Mefford and Mindy Mallory
Series/Article ID:	*PAER-2021-3*
Date:	April 22, 2021
Tags:	COVID-19, Price Analysis, Cattle Markets
Summary:	Taking a closer look at the relationship between cattle futures and financial markets during the spring of 2020.

The market adage "all correlations go to one in a crisis" refers to uniform financial market declines during times of extreme volatility. Essentially, unrelated assets may be traded as a group due to fears of the unknown. This appeared to be true in March of 2020. Faced with unprecedented uncertainty due to the Covid-19 pandemic, markets responded with sell offs across all asset classes, regardless of their susceptibility to the virus. Figure 2 shows the June contract for the E-Mini S&P 500 futures contract, which experienced dramatic falls throughout much of March. Similar drops were seen in agriculture futures exemplified by figure 3, showing the movements in the cattle crush spread. The cattle crush spread is a hedging tool composed of futures contracts for live cattle (LE), feeder cattle (GF) and corn (CZ) that measures the profitability of finishing beef calves.

The decline seen in cattle markets was popularly attributed to the shutdown of beef packing plants due to Covid outbreaks among their workers. The earliest plant shutdowns occurred at the end of March and continued through April (Reuters, 2020). Weekly cattle slaughter numbers reached a yearly low during the first week of May (Martinez et al., 2020). However, as seen in figure 3 many of the initial drops in the cattle crush spreads came in mid-March, coincident with declines in the S&P 500. Our research tests whether the cattle crush spread became correlated with broader equity markets during the COVID-19 stock market crash in March 2020. To this end we test for cointegration, a concept defining equilibrium between two or more price series. We examine the relationship of four cattle crush spreads that were trading at the time of the crisis and the June E-Mini S&P futures contract.

Figure 1: Description of Contracts used in Study

Contracts used	Description
Feeder Cattle (GF)	One contract represents 50,000 lbs of beef calves weighing between 700 and 900 lbs. The calves will be finished at feed lots to increase weight
Live Cattle (LE)	The next step for calves. One contract is made up of 40,000 lbs of finished, or live cattle. Live cattle are finished calves weighing between 1,050 and 1,500 lbs and are slaughtered after leaving the feedlot.
Corn (CZ)	One contract constitutes 5,000 bushels of corn. Corn makes up about 75% of cattle feed.
E-Mini S&P 500	This contract tracks the S&P 500 index. The E-mini contract is the most popular S&P futures contract.

Figure 2: June S&P E-Mini Futures Contract, January to June

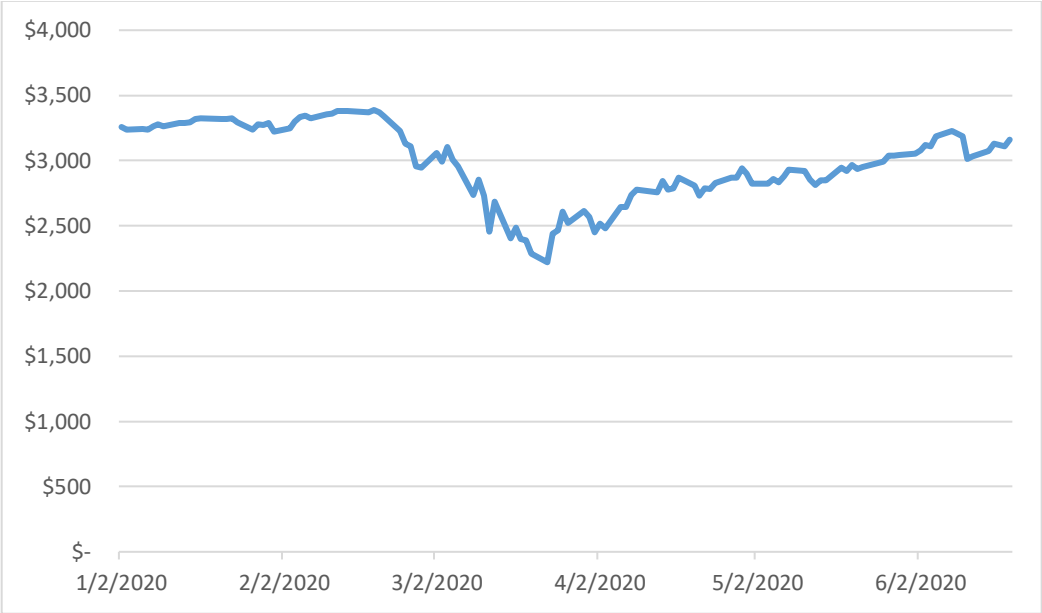
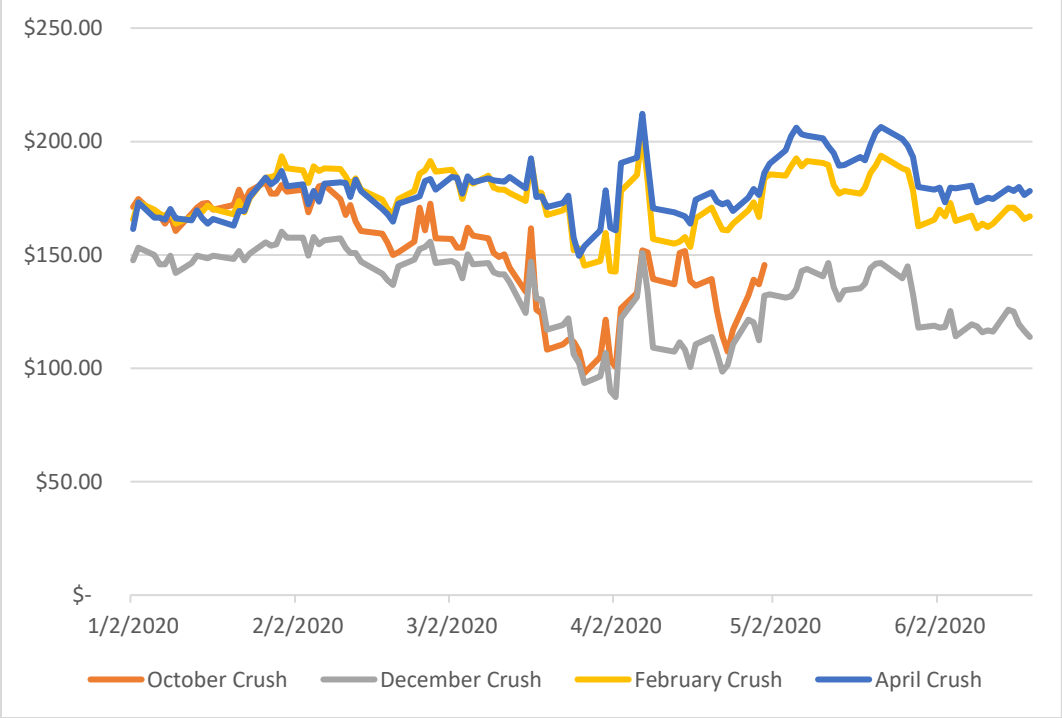


Figure 3: Cattle Crush Spreads, January to June



Visual Analysis of the Spread

Seen in figures 3 through 6, the spreads and their included contracts experience a slow decline before having an initial crash in late March, similar to the S&P 500. Packing plants began to shutdown during the beginning of April which coincides with the steep drop on April 2nd (Reuters, 2020). Figures 4 though 6 show how GF and LE futures quickly rebounded after this drop, while corn futures took until early summer before picking back up.

Figure 4: Live Cattle Contracts, January to June

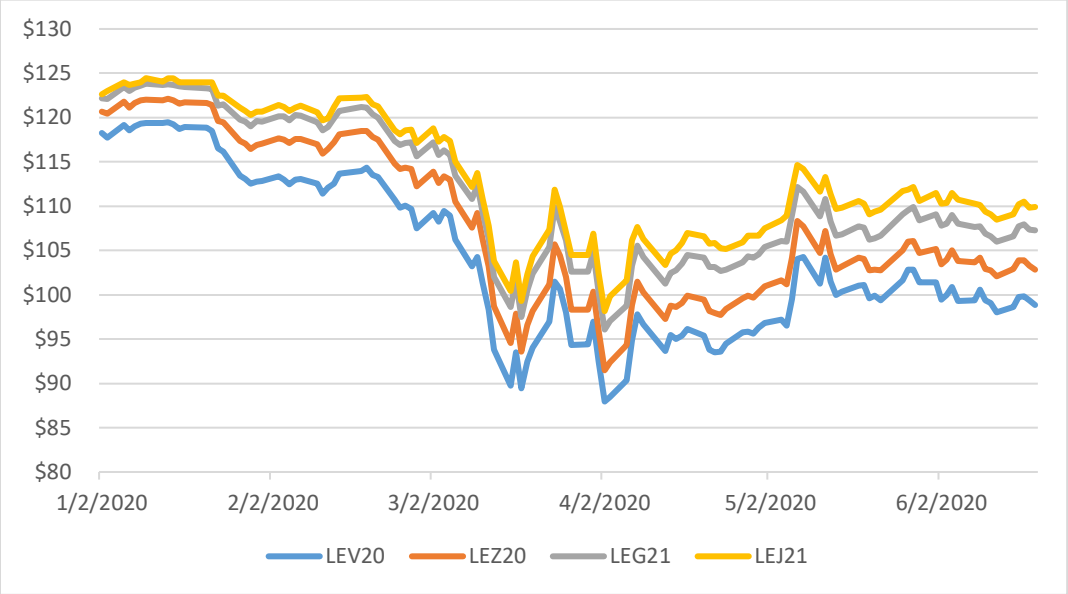


Figure 5: Feeder Cattle Contracts, January to June

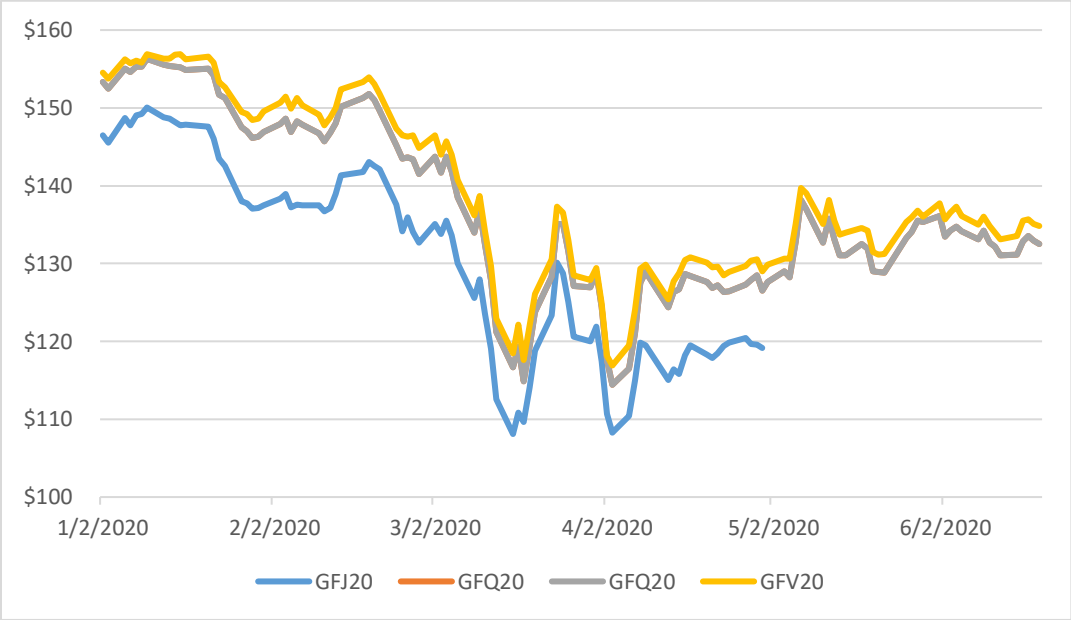
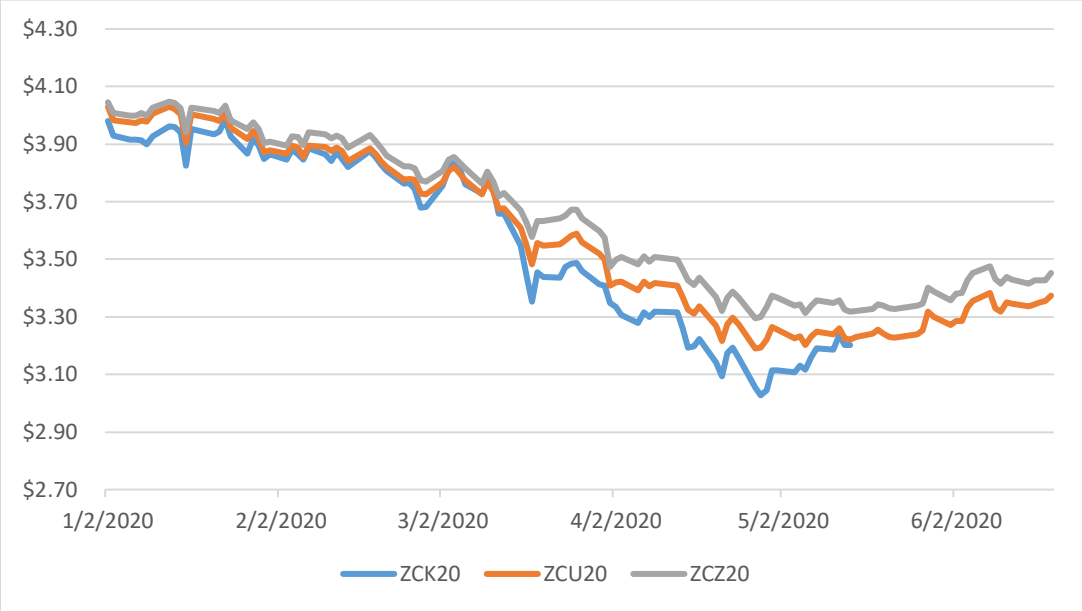


Figure 6: Corn Contracts, January to June



Shown in figures 4 through 6, cattle futures rose through the rest of the spring even with the occurrence of more packing plant shutdowns. This rise goes against the theory that plant shutdowns had large effects on the cattle crush spread. LE contracts are made up of cattle ready to be slaughtered and slaughter rates were declining during April so in turn LE futures prices should have been falling as there would be no market the ready to be slaughtered cattle (Martinez et al., 2020**)**. At the same time feedlots who would be struggling to sell off their finished cattle would in turn slow down purchases of feeder calves so GF prices would also decline (Martinez et al., 2020**)**. Despite the bearish situation cattle contracts rose steadily through April into May. Never again reaching their March or early April lows

Data and Methodology

The cattle crush spread tracks the key points in the cattle finishing process. The CME live cattle contract is composed of 40,000 pounds of finished calves ready for slaughter. The other cattle contract is the CME feeder cattle contract made up of 50,000 pounds of calves destined for feedlots. We chose GF contract expirations such that the GF contract expires between four and six months before the LE contract to allow for adequate time the feeders to reach finished weight. Corn futures contracts are included in the spread to account for feeding costs. Finishing rations are about 75% corn and is purchased closer to the GF contact expiration.

We use an 8-4-2 spread combination in our study. This represents eight LE contracts, four GF contracts and two CZ contracts. This combination can hedge approximately 266 animals placed at 750 lbs, marketed at 1,250 lbs and fed 10,678 bushels of corn. The spread acts a gross profit equation for feedlots with their output, LE, minus two of their main inputs, GF and CZ (Steiner). The total is then divided by 266 to give the result on a per calve basis.

$$Spread = \frac{(Live\ Cattle\ \$ * 8 * 400) - (Feeder\ Cattle\ \$ * 4 * 500) - (Corn\ \$ * 2 * 5000)}{266}$$

Since several expirations of the cattle spread were trading at the time of the March 2020 COVID-19 crisis, we refer to the spreads based on the expiration of their live cattle contract. The spreads we looked at were October 2020, December 2020, February 2021, and April 2021. These spreads were chosen because each constituent contract was trading during the date range we analyzed, which ran from January 1st, 2020 to June 19th, 2020.

The study time of January to June was divided into four sub areas for more detailed analysis and allowing the results to be compared between each of the time periods. Using a breakpoint test the time periods were set up as follows: January 1st to February 23rd, February 24th to March 18th, March 19th to April 29th and then April 30th to the end of our study on June 19th. The October spread includes the April feeder cattle contract which stops trading on April 30th, so we were unable to study cointegration in the last period for the October spread.

Figure 7: Cointergation Among Cattle Spread Constituents and S&P 500

Spread	Cointegration for the whole Series	1/01/2020-2/23/2020	2/24/2020-3/18/2020	3/19/2020-4/29/2020	4/30/2020-6/19/2020
October Spread	***		**		Not enough data
December Spread	***		**	**	**
February Spread	***	*	***	***	*
April Spread	***		***	***	

Null = series is not cointegrated; * - Significant at the 10% level; ** - Significant at the 5% level; *** - Significant at the 1% level

Cointegreation Tests

All combinations of spreads and the S&P futures contract we look at are cointegrated to the 1% level over the whole time period of the study. Out of all the spreads, February is the only one to have evidence of cointegration during the January to February time frame. All four spreads are cointegrated to at least the 5% level during the time periods of February to March and three spreads are cointegrated from March to April. The December and February spreads continue to exhibit cointegration in the last time period of April to July.

Our analysis confirms that the cattle crush spreads and the June S&P 500 E-mini futures contract were cointegrated during the beginning of the Covid-19 pandemic. As it is unlikely that the S&P was being driven by cattle futures; it can be safe to conclude that the movements of the S&P had an impact on cattle futures. Despite the visual similarities and the cointegreation results there is no clear way to determine what exactly drove prices and it is probable that fears of production delays had a large role.

Discussion

Our analysis shows that the cattle crush spread became cointegrated with the S&P 500 futures during the March 2020 COVID 19 crisis in U.S. equity markets. It appears this crisis-driven equilibrium relationship is an instance of the phenomenon, "All Correlations go to 1 in a Crisis". The cattle crush spread is not typically related to the broader equity markets, rather dramatic swings in the spread can typically be attributed to a supply or demand factor directly related to cattle markets. The initial drop in the crush spread coincides with the equity market crash, which began a full month before the idling of capacity in beef slaughterhouses.

Citations:

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Steiner, Len "THE CATTLE CRUSH AND REVERSE CRUSH: An Industry Hedging Tool And A Financial Investment Opportunity". *CME*

Reuters Staff. "Factbox: Spread of coronavirus closes North American meat plants." *Reuters*, 13 Apr 2020.

PURDUE
AGRICULTURAL ECONOMICS
REPORT

Title:	Farmland Market Experts Do Not Want to Over-predict Farmland Price Growth
Authors:	Chad Fiechter, Brady Brewer, Todd H. Kuethe
Series/Article ID:	*PAER-2021-4*
Date:	April 22, 2021
Tags:	Farmland price expectations, farmland value, rational expectations, asymmetric loss
Summary	We find that appraisers, ag lenders, and other farmland market experts do not want to over-predict future farmland values. When making financial decisions or interacting with appraisers and ag lenders it is important to understand the existence of this conservative bias.
Related article:	Kuethe, T.H., B. Brewer, and C. Fiechter (2021). Loss Aversion in Farmland Price Expectations. *Land Economics,* Forthcoming.

Farmland is the largest asset of the farm sector balance sheet. According to the USDA, farmland constitutes approximately 83% of farm sector assets (USDA Economic Research Service, 2020). As a result, farmland is an important factor for farm financial decision making. When farmland values are expected to increase, farmland owners leverage existing land holdings to purchase more farmland (Weber and Key, 2014, 2015), and lenders provide more credit to the agricultural sector (Briggeman et al., 2009). Thus, the expected value of farmland is an important driver in investment decisions for bankers, farmers and landlords.

Expectations are an important area of inquiry for economists from many fields. One of the most prominent economic models of expectations is rational expectations (Muth, 1961). The rational expectations hypothesis posits that agents form expectations using all available sources of information efficiently, just like any other scarce resource or input. In contrast, the theory of naïve expectations assumes that the future value is the same as the value exhibited today. Naïve expectations therefore do not include all currently available information. Economists have developed models for how agents incorporate information into their *rational expectations* of asset values. These models provide a series of tests to evaluate the ability of the theory to explain what we observe happening. The tests utilize the difference between expected and observed values, or the expectations' errors.

Economic theory suggests that expectation errors should be random or free of a set pattern. Expectation errors can have patterns in two ways. The first pattern we check for is that errors do not have an equal chance of being positive or negative. This implies that the expectations have a tendency to over-predict

or under-predict observed outcomes. In other words, expectations are biased. Second, expectations can repeat over time. Over- or under-predicting in one period leads to predictable over- or under-prediction in subsequent periods. A predictable error pattern is evidence that expectations are inefficient. Previous studies have shown farmland price expectations to be irrational, both in bias and efficiency (Kuethe and Hubbs, 2017; Kuethe and Oppendahl, 2020). In a recent study, we examine the degree to which prior findings of irrationality are the results of restrictive assumptions made in testing of expectations by prior researchers. Traditional expectation tests assume that individuals consider both an over-prediction error and an under-prediction error equally, or as economists state, their loss functions are symmetric. If positive and negative errors generated different costs, then expectations may be rational once these asymmetries are considered (Elliott et. al., 2005). In other words, asymmetric loss considers the possibility that either under-prediction errors or over-predictions errors may be considered worse to the individual. This idea is similar to the economic concept of Prospect Theory developed by Kahneman and Tversky, (1979). Prospect theory suggests that individuals may not react equally to similar sized gains or losses. As an example, *winning* five dollars may not be as *good* as *losing* five dollars is *bad*.

Analysis

We test the rationality of farmland price expectation of Indiana farmland experts collected in the *Purdue Land Value and Cash Rent Survey.* Each June the survey is completed by farm managers, appraisers, land brokers, agricultural loan officers, cooperative extension personnel, and other farmland experts. Farmland experts provide farmland values for (1) the previous December, (2) the current June time period, and (3) the expectation of the coming December. These categories are requested for farmland values of (1) top quality, (2) average quality, and (3) poor quality farmland. Additionally, the survey segments Indiana into six agricultural production regions. Expectation errors are calculated by taking information from consecutive years. For example, in June 2019, the expected change in top quality farmland for 2019 in West Central Indiana is -0.8% (Dobbins (2019)), and then observed to be 2.0% in June of 2020 (Kuethe and Dobbins (2020)). These two values equate to an expectation error of 2.8%. A series of expectation errors are constructed at the state and regional level for top, average, and poor quality farmland, using survey responses from 1979 to 2020. During this period farmland values have experienced significant changes, such as the 1970's-1980's boom-bust cycle and the rapid appreciation during the commodity price boom of the early 2000's (Henderson et al., 2011, Kuethe and Hubbs, 2020).

Under conventional symmetric loss tests, 68% of farmland value expectations series exhibited bias and 55% of the expectation series exhibited information inefficiency, or repeated mistakes. Taken together, 73% of farmland expectations series can not be considered rational, consistent with the previous studies. When we allow for potential differences in the costs of under-predicting or over-predicting farmland values, these series are shown to be unbiased and efficient. Specifically, we find that farmland experts experience more loss for the over-prediction of farmland values than under-prediction. Over-prediction is estimated to be in the range of 3 to 5.7 times more costly than under-prediction. In other words, farmland market experts would strongly prefer to under-predict future values relative to over-predicting them. These results seem intuitive, especially with regard to agricultural bankers. Consider the role price expectation's play when lenders establish the collateral needed in a farmland loan. If a banker under-predicts the future value of the farmland, the result would be an advantageous position of holding more

valuable collateral. By contrast, if a bank over-predicts, they may find themselves with overvalued collateral, deficient in meeting required federal capital regulations.

Asymmetric loss in the expectations of farmland values could have many implications for the agricultural sector. In the example of the over-prediction averse banker, their aversion to loss makes sense for the financial health of the bank, as well as the financial health of the borrower. A farmland expert's conservative nature may help to shield the agricultural economy against a potential crisis, yet it may also create an unjustified credit limit for the agricultural economy. For example, Briggeman et al. (2009) suggests that U.S. agricultural production is 3% less, due to the lack of necessary credit. In addition, our study suggests that farmland owners should consider the potential for asymmetric loss when considering others' expectations of farmland values. When making financial decisions or interacting with appraisers and ag lenders, it is likely that their expectations of farmland values will be conservatively biased.

Further Reading:

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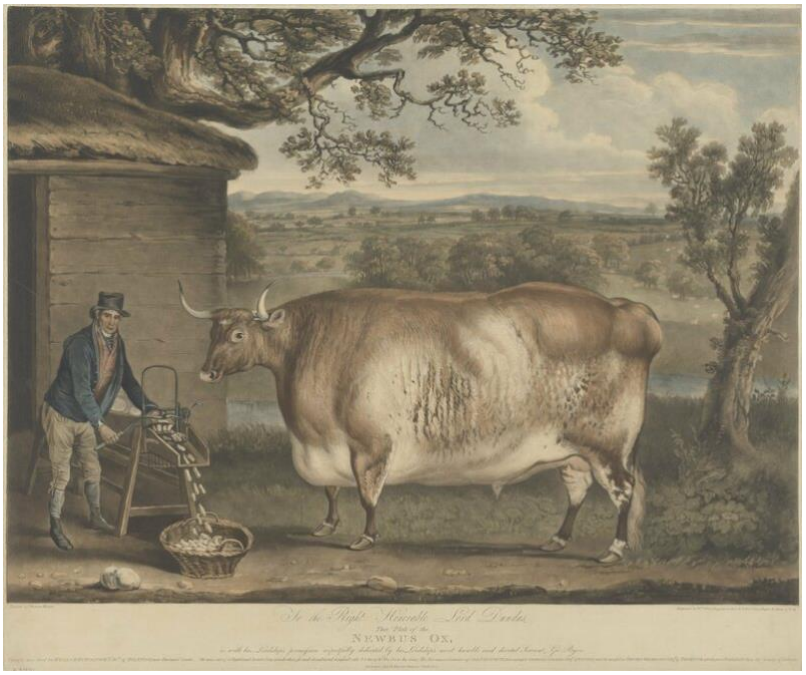
PURDUE
AGRICULTURAL ECONOMICS
REPORT

Title:	A Gentle Critique of Agricultural Supply Theory
Author(s):	Mario Ortez
Series/Article ID:	*PAER-2021-5*
Date:	April 22, 2021
Summary:	Can farmers alter the supply of agricultural products in the very short run? They may!

Established Agricultural Supply Theory says that "In the *very short run*, by definition, the supply function (of agricultural products) is a vertical line" (Tomek and Robinson, 2003) or that it is perfectly inelastic -perfectly unresponsive to price changes-. What this means in lay terms is that the aggregate of farmers can not immediately alter their immediate supply to the market, given a price change. I propose that in fact, they can!

Tomek and Robinson (2003) discuss that the length of the *very short run* time period for an annual crop, is the crop year, and production cannot be changed until the next crop year. I believe that this definition of the supply curve, based on the biological cycle of production, may miss the marketing timing aspect. By way of an example, in the *very short run*, a sharp increase in live cattle prices, may indeed increase the supply of live cattle to the market in the immediate term. Ranchers can choose to market a higher number of steers and heifers, even maybe some of them that are not fully finished, and hence in the absence of the live cattle price increase, they would have otherwise stayed in the pens longer. Or in light of a decrease in live cattle prices, ranchers can choose to retain the heads that were supposed to be marketed in the very short run, feed them longer, and possibly market them shortly after. In a similar way, think of a corn farmer waiting a few more days to harvest, or a meat packer reducing the schedule kill as an immediate response to a price decrease. After all, don't all of us farmers always hope that prices will go up?



William Ward (1812). The Newbus Ox. Yale Center For British Art. Public Domain

My argument here is not that suppliers can alter the supply indefinitely, but that they can certainly alter it, at least for a short while and that our theory does not reflect the reality of modern agricultural markets in this regard. Ranchers could wait to market their cattle another few weeks, grain farmers maybe a bit less. In any regard, our supply theory largely misses this possibility. As the editor of this article kindly noted, this possibility may call into question short run policy models that adopt a vertical supply function approach or perhaps the teaching of economic principals in the classroom, where students may recognize that this theory may not reflect the reality of the industry.

But let's revisit our Supply theory for a little bit. For a corn example it says that if price for corn changes today, corn farmers **can not** alter their supply to the market in the *very short run*, can alter a little their supply to the market in the *short run* and lastly, can alter quite a bit their supply to the market in the *long run*. The theory accurately represents the biological nature of agricultural production, meaning that it takes time to plant a seed or raise a heifer. In this spirit, the theory was built to reflect that in the very short run, there is not time to do all those things, hence supply is fixed.

Maybe the theory resembles a world where suppliers are already physically in the marketplace with their product, that they have to sell their product then, and only then they know the price they would get, hence price changes in the *very short run* may have no effect on quantity supplied. However, in our modern world, suppliers access their prices from the comfort of their homes, or of their farms, and they make the decision to trade base on that.

Reference:

Tomek, William G & Robinson, Kenneth L., 1921- (2003). Agricultural product prices (4th ed). Cornell University Press, Ithaca, N.Y

PURDUE
AGRICULTURAL ECONOMICS
REPORT

Title: Is the public willing to pay to curb microplastic pollution?

Authors: DongWhoi Moon and H. Holly Wang

Issue: PAER-2021-6
Date: April 22, 2021
Summary: This study has examined the U.S. public's knowledge and concerns about microplastic pollution. The findings from this study indicate that while the public are not widely aware of microplastic pollution, they are willing to take action to mitigate risks related to such pollution once they have been informed.

Introduction

Microplastics are plastic particles less than 5mm in size in any one dimension (Arthur, Baker and Bamford, 2009), and can be found in most waterbodies. Microplastics bind with compounds containing toxins in the water, providing these toxins with a route into the human body (World Economic Forum, 2018). Many microplastic particles are around (or smaller than) the size of plankton, the primary source of food for many marine lifeforms. Therefore, toxins are accumulated through the marine life food pyramid and are eventually consumed by humans.

People eating seafood are ingesting up to 11,000 pieces of microplastic particles every year (World Economic Forum, 2018). Given such circumstances, will individuals be motivated to curb this potential threat? On a side note, it is important to identify which type of individuals have higher willingness to lessen microplastic pollution than others, from a policy perspective.

Analysis and Results

To ascertain consumer Willingness-To-Pay (WTP) to curb microplastic pollution, a survey[1] in which the sampled respondents were asked if they were willing to pay a certain amount of a new annual environmental tax for such a purpose was undertaken. Respondents were first asked their foreknowledge regarding microplastics. It was found that 60% of the respondents have not heard about microplastics at all, while 40% have. We gave the 60% respondents a general explanation of microplastics, while omitting specific mention of potential deleterious effects on individual health. 90% of the respondents

[1] The survey sample was a targeted quota sample, with gender, age, region, ethnicity, education level, and income level accounted for and set to resemble the percentages found for the U.S. population in the last census. The survey was conducted from July 2020 to August 2020, with the sample size being 580. More details available upon request, from the authors.

think that microplastics will harm their health. It should be noted that regardless of whether the respondent has heard about microplastics or not, about 90% of the respondents in both heard and not heard groups think microplastics is harmful. The survey then exposed different respondents to 3 different types of information regarding pollution levels,[2] after which the respondents were asked a series of questions designed to elicit their WTP[3].

The other parts of the survey elicited 1) the attitudes/behaviors towards the environment; 2) WTP for items with other alternative ecolabels, such as organic; 3) the taxes that need to be levied on potentially harmful items, such as climate change inducing items; 4) the health consciousness of each individual; 5) how knowledgeable each respondent is about microplastics, especially about microplastic clothing fibers; and 6) their attitudes/behaviors towards plastics and microplastics.

Tables 1 and 2 below show various information elicited in the survey. Samples falling into each category for the categorical variables are reported in Table 1.

Table 1. Categorical Information, Percentages

Information Type	Subcategory	Percentage
Real Estate Ownership	Own	61%
	Not Own	39%
Ever Heard About Microplastics?	Yes	40%
	No	60%
Will Microplastics Cause Harm to You?	Yes	90%
	No	10%
Check for contaminants before seafood purchase?	I Do Not Buy or Eat Seafood	20%
	Yes	29%
	No	51%
Information Treatment: Number of microplastic particles encountered per day, from water usage alone	Low Treatment: 225	32%
	Middle Treatment:705	33%
	High Treatment: 3885	35%

Table 2 presents the mean and the median of continuous variables used in this analysis. WTP has a mean of 0.86, which means on average, the individuals sampled were willing to pay $0.86 annual tax to reduce microplastic pollution by 1%. However, the distribution of the WTP variable is skewed, with 24% of the respondents having 0 WTP and 5% of the respondents having an outlier value of 10. Therefore, the median WTP of $0.40 annual tax is a more accurate statistic for the WTP values.

[2] The information treatment given to respondents: The average U.S. resident encounters about 705 microplastic clothing fiber particles per day, from using water for everyday activities such as cooking and drinking. This figure is based on an increasing rate of pollution of 72,000,000 microplastic particles per day. The wording is the same in all three categories, with the underlined numbers changing, as listed in Table 1.

[3] The WTP was elicited using a hierarchical design. More details about the design available from the authors, upon request.

Table 2. Continuous Variable Information

Information Type	Mean	50 Percentile
WTP	0.86	0.40
Number of Adults in the Household	2.17	2.00
Number of Kids in the Household	0.63	0.00
Hours/Week Spent on Volunteering for Environmental Protection	1.45	0.00
Q16Score	15.60	16.00
EnvstateScore	26.24	26.00
Clothplastic2Score	8.87	9.00
Health2Score	7.43	8.00
Dmlabpc1	0.00	-0.82
Dmlabpc2	0.00	-0.12
Dmtaxpc1	0.00	-0.72
Dmtaxpc2	0.00	-0.26

The Q16Score is the summation of responses to a set of questions about pollution control. The aggregate scores for respondents range from 4 to 20 with higher scores indicating a more pro-plastic-control attitude. EnvstateScore is generated like the Q16score, but focuses on attitudes about general environmental protection, ranging from 7 to 35. Clothplastic2Score is an index we create from questions about clothing choices or behaviors that may increase microplastic pollution. These questions measure awareness of microplastic pollution with higher scores indicating higher awareness. Health2Score was calculated in the same way using 4 questions about individual health consciousness and behaviors[4]. The last four variables are the first and second principal components which we use as indices of the willingness to pay for items with other alternative labels, such as Non-GMO and organic, and the taxes each respondent thinks need to be levied on potentially harmful items to the environment or individuals, such as climate change inducing items.[5]

The WTP variable had a significant number of individuals with zero marginal WTP, in which 140 out of 580 individuals had 0 WTP. To account for this high number of zero responses, a Tobit regression model was used to analyze the causal effect of the factors on WTP, with the lower bound set at 0. The model results are shown on Table 3 below.

We found that exposing respondents to differing information regarding the severity of the microplastic problem had a significant effect. Respondents being informed that the microplastic pollution levels were low and average expressed about 24.5 cents lower WTP than those in the high pollution information group. These results are reasonable because higher pollution will urge people to pay more to control it.

In terms of demographics, those who identified as Hispanic and Asian, those who chose 'other' as their marriage status, and those who resided in the South or Midwest regions at the time of the survey had higher WTP than those who did not fall into these categories. Due to the study being framed in a water pollution setting, it was expected that the Asian racial category will have higher WTP than other groups due to this group having the highest seafood consumption (Terry et al., 2018). The difference in WTPs between marriage status groups might be partially explained by the fact that those who lead alternative lifestyles tend to be politically liberal, who typically care more about environment protection than more

[4] More details on the distribution of the response and about these indices are available from the authors, upon request.

[5] Principal components are perpendicular axes of the space spanned by the variables of interest, where the axes explain the variance of the variables of interest, in a decreasing order of magnitude. Principal components analysis is used to reduce the dimensionality of datasets, due to limited sample size and to avoid overloading the model. (James et. al., 2013)

conservative individuals, who are more likely to be in traditional marriages (Funk and Kennedy, 2020; Schnabel, 2018).

Table 3. Tobit Regression Results

Independent Variable	Average Partial Effect	Standard Error
Male	+0.0780	0.1103
Age	-0.0053	0.0036
Education	-0.0437	0.0291
Income	+0.0000	0.0000
Number of Adults in the Household	+0.0215	0.0530
Number of Kids in the Household	-0.0667	0.0612
Real Estate Ownership	-0.1538	0.1383
Full Time Student Status	-0.0430	0.2082
Have Heard About Microplastics	+0.0256	0.1154
Microplastics Will Cause Harm to Me	+0.0226	0.1829
Low Information Treatment	-0.2425*	0.1294
Middle Information Treatment	-0.2479*	0.1282
Q16Score	-0.0349**	0.0173
EnvstateScore	+0.0072	0.0106
Clothplastic2Score	+0.1057**	0.0439
Health2score	+0.1450***	0.0453
Hours/Week Spent on Volunteering for Environmental Protection	+0.0320**	0.0131
Dmlabpc1	+0.0644*	0.0345
Dmlabpc2	-0.0035	0.0858
Dmtaxpc1	+0.1066***	0.0357
Dmtaxpc2	+0.1150	0.0739
Every Other Race	-0.4825**	0.1940
Asian	-0.3799	0.2565
Black or African American	-0.4053**	0.1855
Non-Hispanic White	-0.4517**	0.1856
Not Married	-0.6730***	0.2216
Married	-0.5105**	0.2390
I Do Not Buy or Eat Seafood	-0.9543***	0.1109
I Check for Seafood Contaminants before Purchase	+0.2618**	0.1360
Northeast Region of the US	-0.3667**	0.1600
South Region of the US	-0.1574	0.1530
Western Region of the US	-0.3445**	0.1558
Constant	+1.4057	1.5826

Note: *=10%, **=5%, ***=1% statistical significance

For the seafood category, those who answered ‘I do not buy or eat seafood’ had on average 95 cents lower WTP than those who answered ‘no’ to whether or not they check seafood contaminants before purchase. Those who answered ‘yes’ had on average 26 cents (per 1% pollution reduction) more WTP

than those who answered 'no'. This follows an expected pattern, with those who are more sensitive about pollution in seafood showing the highest WTP.

It was also found that those who spend their time outside of work on environmental protection volunteer work, are more health conscious, or have less microplastic increasing clothing habits have higher WTP for microplastic reduction than those who do not. In addition, while both Dmlabpc1 and Dmtaxpc1 are statistically significant, the taxes principal component (PC) has twice the effects on WTP as the labels PC and is more significant. This is not surprising, since the study is about a new tax to decrease microplastic pollution[6].

Summary

The overall median WTP was $0.40 new annual household tax for a 1% reduction in pollution. Our results show that about 40% of the respondents were aware of microplastics at the time of this study, and that regardless of previous knowledge about microplastics, 90% believe they are harmful. The results also show that disseminating information showing severity of microplastic pollution can increase the individual WTP for microplastic reduction. This result calls for public education about microplastic pollution to bring this problem to people's attention and to increase the public's WTP to lessen microplastics in waterbodies. An individual's behavior related to environmental protection, individual's perceptions and behaviors regarding microplastics from clothing, their health consciousness, their attention to seafood contamination, and whether or not they had WTP for alternative labelled goods or taxes were also good indicators of higher WTP for microplastic pollution reduction.

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[6] Specific details and numbers available upon request, from the authors.

PURDUE
AGRICULTURAL ECONOMICS
REPORT

Title:	Sustainability, productivity, and market access of smallholder sugarcane farmers: The Case of Central America
Author(s):	Mario Ortez, Nhu (Claire) Nguyen and Zachary T. Neuhofer
Series/Article ID:	PAER-2021-7
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Summary	How can sugarcane farmers sustainability, productivity, and market access? We advocate for cooperatives, weather/soil maps, byproduct utilization and seed engineering.

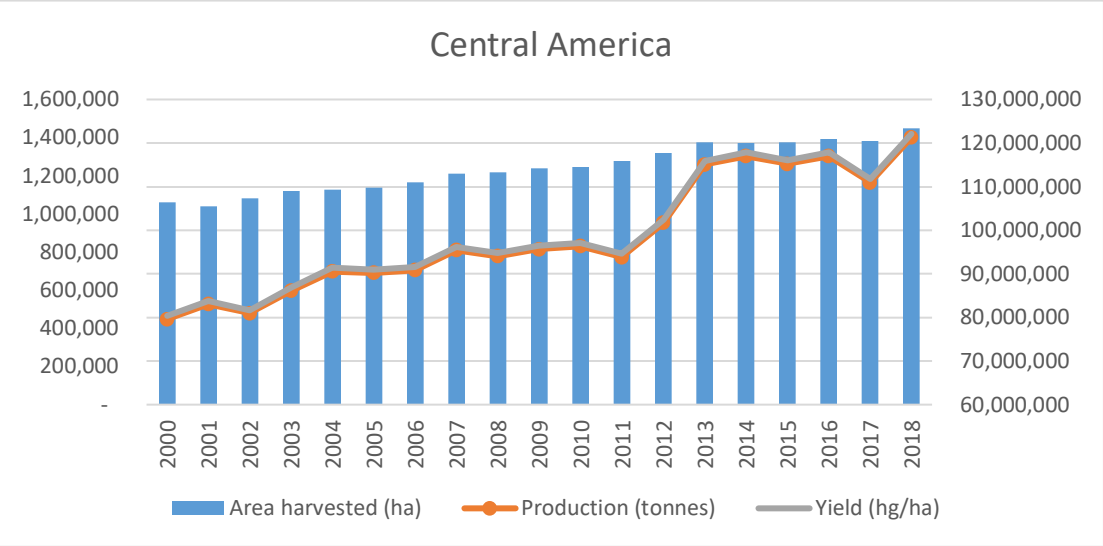
We start this essay by defining the terms productivity and sustainability and establishing a vital bond between them. We then introduce and defend the strategic decision of analyzing the case of smallholder sugarcane farmers in Central America (C.A.) as a way to provide with meaningful contributions to the main question. The remainder of the essay will provide short- and long-term solutions to improve outcomes. In the short term we argue for the formation of farmer organizations and technology adoption that will in the long-term assist in the development of seed engineering technology and byproduct optimization as accessible, efficient, and key elements to improve sustainability, productivity, and market access of smallholder sugarcane farmers.

The traditional idea of "productivity" includes increasing output using less (or the same amount) input. Food economist Jayson Lusk argued that productivity is an often-forgotten cornerstone of "sustainability" (Lusk, 2017). He argues that by increasing productivity we also increase sustainability in the production of agricultural products. In our essay, when the word "sustainability" is used, it will mean the creative process that allows for the possibility of the growing of sugar cane to endure and remain productive over time. Eminent economist and business professor Julian Simon, poured out his belief that human ingenuity has been and will continue to be one of the main drivers of productivity. Simon (1981) credits agricultural knowledge gained from research, development induced by the increased demand, and the ability of farmers to get their produce to market on improved transportation systems, as the key drivers for output and productivity per worker and acre to increase from the 1970's onward. This trust of human ingenuity can lead to continued improvement upon the outstanding problems facing sugarcane small holders in C.A.

Small holders, as defined by The Food and Agricultural Organization (FAO), are small scale farmers who manage areas varying from less than 1 to 10 hectares (FAO, 2012). We focus on the current situation of small holder farmers in C.A. and primarily focus on local solutions rather than expansive global projects that require more coordination to implement. We choose C.A. because (1) it is the third largest producing region of Sugarcane in the world (FAOSTAT, 2020a) and (2), according to FAO,

developing countries are leading the per capita global increase in sugar consumption, which implies that for the producing countries in C.A., this crop is not only an important export product, but is also consumed domestically.

Figure 1. Central America's Production, yield and area planted.



Source: FAOstat

Sugarcane provides approximately 80% of the world sugar supply and is also used as raw material for ethanol production in countries like the United States and Brazil. In C.A. from 2000 to 2018, yields (tons/ha) have trended upwards and increased over 10% from 75 tons/ha in 2000 to 83.7 tons/ha in 2018 (FAOSTAT, 2020a). Using yields as a parameter of productivity, this region is the second most productive region in the world, just below North America. Additionally, in C.A. , the total area harvested increased by a factor of 36% from the year 2000 to 2018 while production (in tons) increased by a factor of 52% (FAOSTAT, 2020b). This seems to be an increase in productivity and sustainability from the land usage perspective. We now turn to specific ideas to build upon this momentum.

A case for cooperatives:

A cooperative is typically defined as an "autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly owned democratically controlled enterprise" (ICA, 2005). The commonly stated benefits of cooperatives are taking advantage of increased economies of scale, enhancement of the competitiveness of small farmer's products, and promoting innovation (Deininger, 1995). Many studies in various developing countries have shown that farmers benefit from cooperatives (Abdulquadri & Mohammed, 2012; Fischer & Qaim, 2012; Shiferaw, B., Obare, G., Muricho, G. and Silim, 2009; Vandeplas et al., 2013; Verhofstadt & Maertens, 2014; Wollni & Zeller, 2007). Others show that cooperatives have failed in some cases at improving smallholder outcomes, but if done correctly, the benefits of membership likely outweigh the costs (Barrett, 2008; Markelova et al., 2009; Poulton et al., 2010). An important factor for cooperatives to be successful is the formation and design. Typically, the most successful cooperatives are primarily focused on the marketing of products, providing resources for inputs such as new technologies, scientific developments, supply chain logistics, land acquisition, and improved market access. These benefits in turn provide higher sale prices from the joint marketing and cheaper input costs from the resources provided (Fischer & Qaim, 2012; Getnet & Anullo, 2012; Shiferaw, B., Obare, G., Muricho, G. and Silim, 2009).

In the case of smallholder sugarcane farmers in C.A., cooperatives may help to decrease transaction costs, similar to the case of vegetables (Hellin et al., 2009). The cooperatives should focus on joint marketing of sugarcane from smallholder producers to increase individual farm incomes and prices. To reduce the supply chain costs, the cooperatives can pool resources to reduce transportation and input costs. The production of the farms should be individual to maintain incentives. Another focus of the cooperatives should be the adoption of technology that is lacking in C.A. such as seed engineering and other prominent technologies common to developed countries.

Development and adoption of soil and weather maps:

The strategic planning of where and when to plant sugar cane can be influenced by technology to maximize climate factors. Climate change is arguably challenging the traditional areas that are known to be suitable or ideal for sugar cane (because the temperatures and rain amounts continues to change and also the time of the year when planting is occurring in those traditional areas). Revisiting and mapping which areas are suitable at a given time (given their temperature, rain and other logistics conditions) could be a way improve yields.

A relevant example is soil databases, such as the World Soil Geographic Database (ISRIC) that comprises the features of many land areas around the world. Small holder farmers can benefit from similar databases constructed for their region. To increase the efficiency of the database, non-profit and educational organizations can notify the farmers of the availability of these databases, and teach educational courses that train them to read and interpret the information on soil quality, geographic location, weather patterns, and other related production factors of growing sugarcane. Similarly, a detailed weather and climate database could be constructed for farmers, which would include data on humidity, precipitation, solar radiation, and other related climate factors in the region.

Seed engineering:

Continuing the yields discussion, we now turn to seed engineering, commonly used to improve yields. Seed engineering is also used for other purposes such as, herbicide tolerance and insect resistance, which are of utmost importance to yields, productivity, and sustainability. For example, reductions of herbicide and pesticide use have been shown to decrease production cost and decrease environmental pollution (Singh et al., 2013). Genetic seed engineering means to insert new genes and modify existing ones. The first commercial variety of genetically modified (GM) sugarcane was approved in Brazil in 2017 (Mano, 2017). In 2018, the United States Federal Food and Agricultural Administration (FDA) concluded that sugar made with this variety was safe (Lourencao, 2018). The adoption of GM seeds in developing countries may have political or cultural barriers. The cultural barriers for adoption can be addressed through education about the engineering process, the benefits of using the seeds, (e.g., cost, yields, sugar content, pesticide use, herbicide use, and drought resistance) but most importantly the safeness of commercial sugar from GM varieties.

By-product's usage:

The utilization of byproducts generated by the production and refining of sugar from sugarcane is also a key component of sustainability. Broadly speaking, sugarcane can be processed for both sugar and biofuel (ethanol). Traditionally, sugarcane ethanol is produced from the fermentation of sucrose which occurs after harvest. First the canes are crushed to extract the juice, then the juice is fermented with yeast, finally after a few additional steps ethanol is obtained (Clifford, 2020). However, since this

process involves juice extracted from the canes, it potentially competes directly with sugar production and hence food (Basso et al., 2013; de Castro et al., 2018). Hence, we focus our discussion on bagasse, the fiber component of the cane after extraction. This by-product is composed of approximately 50% cellulose, an important ingredient for producing second generation ethanol, the ethanol that is considered the biofuel with greatest potential to substitute fossil fuels (Basso et al., 2013; Sabiha-Hanim & Halim, 2018). Bagasse can lead to an increase in additional revenues for smallholders, and allows flexibility for farmers in the species of sugarcane produced. Species that have a higher juice content can provide more revenue in the form of sugar, and those that have less juice and more fiber (bagasse) can earn more revenue from bagasse for ethanol production. However, similar to soil and climate database, educational endeavors for small farmers regarding these revenues channels and strategic allocation of resources is imperative.

How about market access?

The ideas that we are proposing are tied directly to the improvement of market access. To be specific, as the body of empirical evidence has shown, association of farmers in a cooperative primarily focused on the marketing of sugar and sugarcane byproducts, will directly affect their ability to market their product more effectively. The ability of a cooperative to invest in research and development (in partnership with Universities, government and NGO's) will allow for the development of seed genetics and the adoption of similar technologies that exist but are not used by small farmers. Lastly, better utilization of sugar cane for the efficient production of sugar and ethanol from the bagasse will be better materialized by the adoption of new processing technologies, distribution of information and lastly better negotiating and marketing through the cooperative.

Concluding, we have discussed how the sustainability, productivity, and market access, of smallholder sugarcane farmers be improved. For the purpose of offering specific ideas, we have used the example of small holder sugar cane farmers in C.A as the basis of our proposal. Narrowing down to this region has allowed us to understand the complexities of small holder sugar cane production in an important sugar cane producing part of the world. We have discussed 4 potential ways that small holder sugar cane farmers can improve their production and revenues: (1) the formation of a cooperative as a strategic way to achieve better marketing of the final products and the sourcing of inputs, (2) research, development, and adoption of seed engineering technology as an opportunity to improve productivity and sustainability through higher yields, less land use, and less inputs used in production, (3) the development and adoption of weather and soil maps as a tool to inform farming decisions, and (4) the optimization of byproducts such as bagasse as an inherent aspect of productivity and sustainability. We would like to close with a quote from American Agronomist, Nobel Peace Prize, Presidential Medal of Freedom and Congressional Gold medal recipient Norman Borlaug quote "There are no miracles in agricultural production". To that we say it is true, but we can only be amazed by the almost miraculous effects that technology and structural organization can have.

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Title: **Award Winning Graduate Student Research at Purdue Ag Econ**
Author(s): Mario Ortez and Roman Keeney
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The year of 2020 was a fruitful year for the Department of Agricultural Economics here at Purdue University and we look forward to 2021 with great excitement. The fruits can be seen in the flourishing of our Doctoral and Master's Graduate students, which in an important way is exemplified in their research endeavors. We, the Purdue Agricultural Economics Report (PAER) editorial board, are pleased to recognize outstanding graduate research at the three levels of degrees that the Department grants, Doctor of Philosophy in Agricultural Economics (PhD), Master of Science in Agricultural Economics (MS) and our MS-MBA in Food and Agribusiness Management hybrid program in collaboration with the Kelly School of Business at Indiana University

The first award-winning graduate that we recognize is Dr. Travis Atkinson, from the Doctoral program. The Department of Agricultural Economics currently has 40 Doctoral Students in residence and 5 completed their program with a successful dissertation defense in 2020. The following summary is for Dr. Atkinson's dissertation titled "*Long-term Infrastructure Investment Planning and Policy Analysis for the Electricity Sector in Small Island Developing States: Case for Jamaica*". A faculty committee selected this as the outstanding Doctoral dissertation in our Department in 2020 and it will compete for

the Agricultural & Applied Economics Association (AAEA) recognition later this summer. Dr. Atkinson's dissertation contributes to our understanding of efficient planning methods for new infrastructure investments as well as energy policies appropriate for small, isolated and often heavily indebted nations, effectively proposing a way to improve long-term planning in the electricity sector in the context of Small Islands Developing States.

The second award-winning graduate that we recognize is Natalie Loduca, from the Master's program. The Department of Agricultural Economics currently has 15 Master's students in residence and 9 completed their program with a successful dissertation defense in 2020. The following summary is Natalie's dissertation titled "*How Scale and Scope of Ecosystem Markets Impacts Permit Trading: Evidence from Partial Equilibrium Modeling in the Chesapeake Bay Watershed*". A faculty committee selected this as the outstanding Master's Thesis in our Department in 2020 and it will compete for the AAEA recognition later this summer. Natalie's dissertation not only utilized but also extended cutting edge techniques in Agricultural Economics to better understand farm level production decisions in the context of a market for environmental quality permit trading. Her research effectively engages and contributes to the ongoing policy discussions regarding ecosystem markets.

The next award-winning graduate that we recognize is Cain Thurmond, from the MS-MBA program. The Department currently has 50 MS-MBA students spread in the two-year program. The following summary is Cain's capstone research titled "*Strategically Positioning CSX Corn Supply Pricing for Profitable Sustainable Growth*". A faculty committee selected this as the outstanding capstone project in the MS-MBA in Food and Agribusiness Management program in 2020. Cain's capstone noted the geographical disparity between corn unit train shippers (located in the Midwest) and feed mill receivers (located in Southern states) and utilized a model to estimate the impact of corn basis prices and freight rates on train traffic flows in the Eastern part of the U.S. Cain's methodological approach contributes to the strategic analysis of the grain sourcing and logistics industry in the U.S.

All in all, we are extremely proud our graduates from this past year and the formation that they received here at Purdue during their graduate studies. We very much appreciate the opportunity that we have in this issue to highlight some of their achievements and how they are contributing to important conversations of different aspects of the Agricultural world, which honors the spirit of our Land-Grant mission here at Purdue.