IMPACT OF COVID-19 ON UNITED STATES MILK PRICES

An Undergraduate Research Scholars Thesis

by

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RESEARCH COMPLIANCE CERTIFICATION

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I, Shelby Lepley, certify that all research compliance requirements related to this Undergraduate Research Scholars thesis have been addressed with my Research Faculty Advisor prior to the collection of any data used in this final thesis submission.

This project did not require approval from the Texas A&M University Research Compliance & Biosafety office.

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ABSTRACT

Impact of COVID-19 on United States Milk Prices

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The impacts of the novel coronavirus-2019, or SARS-CoV-2 (COVID-19), have presented major implications to all industries across the United States. The agricultural field was not immune to these influences. Agricultural producers have witnessed significant changes in policy, management practices, and revenue as a result. Specifically, the dairy-cattle industry has experienced statistically significant fluctuations in the price of its products. The objective of this research was to quantify the impact of the SARS-CoV-2 pandemic on the United States dairy industry via fluid milk price analysis. The data evaluated explains the changes in revenue that United States' fluid milk producers have witnessed during the outbreak and response to the disease. The autoregressive integrated moving average forecast and counterfactual model indicate that fluid milk producers for the United States have lost approximately $0.21436/ctw of fluid milk proudced or $417,656,647.50 across national production from January 2020 to November 2020. As more data becomes avaliable, it is likely that this value could become larger, indicating that even more money was lost for milk processesors, distributors, and retailers given

that they work with value-added milk products rather than the raw materials. Therefore, more research is needed to determine if there were greater losses to the U.S. dairy industry.

DEDICATION

To my friends, families, mentors, and instructors who supported me throughout the research process and encouraged my passion for food production and agricultural security.

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Finally, thanks to my parents, Reggie and Kathy Lepley, for their encouragement, patience, and love.

The data analyzed for the *Impact of COVID-19 on United State Milk Prices* were provided by reports published by the United States Department of Agriculture. The analyses depicted in *Impact of COVID-19 on United State Milk Prices* were conducted in part by the Department of Agricultural Economics at Texas A&M University and are unpublished.

All other work conducted for the thesis was completed by the student independently.

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NOMENCLATURE

ARIMA	Autoregressive Integrated Moving Average
COVID-19	Novel Coronavirus-2019 or SARS-CoV-2
CWT	Hundredweight
USDA	United States Department of Agriculture
USDA ARS	United States Department of Agriculture Agricultural Research Service
USDA ERS	United States Department of Agriculture Economic Research Service
USDA NASS	United States Department of Agriculture National Agricultural Statistics Service
MAPE	Mean Absolute Percentage Error

1. INTRODUCTION

The United States dairy industry has witnessed drastic changes to its structure and production methods throughout the course of its history. Based on the latest data released by USDA Economic Research Service (ERS), there were 9,336 thousand head of cattle used in production during 2019. These cattle were, on average, producing 23,391 pounds of milk per cow (USDA ERS, 2021). Broken down into eleven regions, the dairy industry is made up of the Northeast, Lake States, Corn Belt, Northern Plains, Appalachian, Southeast, Delta States, Southern Plains, Mountain, West Coast, and Other States. Within these regions, the top ten dairy-producing states include California (18.57%), Wisconsin (14.01%), Idaho (7.16%), New York (6.92%), Texas (6.34%), Michigan (5.21%), Pennsylvania (4.63%), Minnesota (4.55%), New Mexico (3.75%), and Washington (3.11%) which make up 74.25% of the total United States milk production (USDA ERS, 2021).

While there is significant variation in dairy farm sizes across the United States, the number of farms and dairy cattle used in production have declined significantly as producers have become more specialized and larger in size. In 2006, it was evaluated that "the number of farms with dairy cows fell steadily and sharply, from 648,000 operations in 1970 to 75,000 … or 88 percent," and "Total dairy cows fell from 12 million in 1970 to 9.1 million," (MacDonald, et al., 2007). Despite these changes, "total milk production rose, and average milk production per farm increased twelvefold," (MacDonald, et al., 2007). This trend has been witnessed more recently because of prevailing cost incentives, such as lower production costs and farm consolidation. From 2002 to 2019, licensed dairy herds fell by more than half and decline rates accelerated from 2018 to 2019 (MacDonald, Law, & Mosheim, Consolidation in U.S. Dairy

Farming, 2020). It is predicted that consolidation will continue, with the dairy producer age increasing and financial stressors continuing in the dairy industry.

Fluctuating input costs and milk prices often produce greater risk for dairy farmers, in addition to the many other market factors that dictate dairy producer's revenue. If input costs lower and milk prices rise, dairy farm revenue can increase. However, this is not always the case. Dairy markets are subject to numerous factors, such as input costs which make their industry volatile. Dairy products' inelastic demand indicates that significant price changes are needed to alter demand and the associated revenue that comes with it. Additionally, factors such as income, population, foreign demand, and marketing can produce changes to demand, as well.

Given the significant contribution of the dairy industry to the United States economy, it is important to address various factors that could affect the dairy industry's performance. In this light, this research aims to describe the monetary impact to United States fluid milk prices brought on by the COVID-19 pandemic. This is essential knowledge and data that will help shape future crisis responses within the agricultural industry. The quantitative analysis of the United States' dairy industry over the last 8 months could have significant implications in the research and policy world. Price evaluation of dairy across the entire country helps facilitate better decision making while identifying issues areas. The economic downturn that occurred in response to the pandemic is unique; therefore, it will be beneficial to study and gather information from this period for further research and understanding. The outcomes of this research shall include a comprehensive look at the entire United States' dairy prices. Further research will be required to quantify the change in price for producers, the consumer, and intermediary dairy supply chain firms.

1.1 COVID-19 Impacts on Agriculture Globally

COVID-19 has initiated disruptions across all areas of daily life for all people. That stated, the impact on food security continues to be experienced. Researchers and citizens are calling for the protection of agricultural products and have said that “It is critical that agricultural inputs, farms, food processing, and distribution are declared essential and exempted from lockdown measures, so that food can flow in adequate amounts from farm to fork,” (Martin, Laborde, Swinnen, & Vos, 2020). Additionally, protocols are needed to protect food chain employees, support transportation, and market engagement. To obtain an efficient amount of monetary support for these requests and raise awareness, the agricultural must collect and analyze pertinent data. There is a need for quantitative data summarizing and explaining the impact that this pandemic has had on various food sectors in the United States. Evaluation of all agricultural value chains is needed.

From a larger perspective, researchers are already evaluating global data. Some researchers have collected survey data that indicates that all activities of dairy production and consumption have been disturbed and “negatively affected the socio-economic condition of the world” (Khan, Fahad, Naushad, & Faisal, 2020). Canada has witnessed the “dumping of milk, the offering of hospitality size goods in grocery stores, and the closure of processing facilities are examples of the disruptions caused by the pandemic to the dairy” (Weersink, von Massow, & McDougall, 2020). Then, in Ethiopia, approximately 100 commercial and small dairy farmers in urban and rural areas, dairy processors, traders, development agents, urban retailers, and consumers showed that the impact that fear of disease risk had on the consumption of dairy. It was reported that “More than half of respondents in the household survey said they were avoiding the consumption of animal-sourced foods (meat, milk, yogurt, cheese) due to the perceived COVID-19 risk," (Agajie, Habte, & Minten, 2020). This information could have implications for the United States export markets but raises concerns to look domestically at consumer perceptions as well.

The COVID-19 pandemic has had a profound impact on society as well as the dairy industry. With this in mind, the general objective of this study is to evaluate the impact of COVID-19 pandemic on the United States dairy prices. Specific objectives of this study are to determine; (i) the patterns in fluid milk prices from January 2011 to November 2020 for the United States before and after the onset of the COVID-19 pandemic and (ii) apply autoregressive integrated moving average (ARIMA) and counterfactual models to forecast the fluid milk prices and determine the loss of revenue for the United States dairy industry due to the pandemic.

1.2 Data

Data for this study was collected by the USDA National Agricultural Statistics Service (NASS). As seen in table 1, this data contains monthly prices received, measured in dollars per hundredweight, for the United States average from January 2011 through November 2020. Additionally, the USDA Economic Research Service (ERS) has provided estimates on the total supply of fluid milk sold by producers. For this study, individual states were not evaluated.

Table 1. *Raw Data: Monthly United States Fluid Milk Prices Received, $/cwt*

Month	**Dollars / cwt**
1/1/11	16.70
2/1/11	19.10
3/1/11	20.40
4/1/11	19.60
5/1/11	19.60
6/1/11	21.20
7/1/11	21.90
8/1/11	22.00
9/1/11	21.10
10/1/11	19.90
11/1/11	20.40
12/1/11	19.80
1/1/12	19.00
2/1/12	17.70
3/1/12	17.20
4/1/12	16.80
5/1/12	16.20
6/1/12	16.20
7/1/12	16.90
8/1/12	18.10

Month	**Dollars / cwt**
1/1/16	16.10
2/1/16	15.70
3/1/16	15.30
4/1/16	15.00
5/1/16	14.50
6/1/16	14.80
7/1/16	16.10
8/1/16	17.10
9/1/16	17.30
10/1/16	16.60
11/1/16	17.60
12/1/16	18.80
1/1/17	18.90
2/1/17	18.50
3/1/17	17.30
4/1/17	16.50
5/1/17	16.70
6/1/17	17.30
7/1/17	17.30
8/1/17	18.00

9/1/12	19.60
10/1/12	21.50
11/1/12	22.00
12/1/12	20.90
1/1/13	19.90
2/1/13	19.50
3/1/13	19.10
4/1/13	19.50
5/1/13	19.70
6/1/13	19.50
7/1/13	19.00
8/1/13	19.50
9/1/13	20.10
10/1/13	20.70
11/1/13	21.60
12/1/13	22.00
1/1/14	23.50
2/1/14	24.90
3/1/14	25.20
4/1/14	25.30
5/1/14	24.20
6/1/14	23.20
7/1/14	23.30

9/1/17	17.80
10/1/17	17.90
11/1/17	18.10
12/1/17	17.20
1/1/18	16.10
2/1/18	15.30
3/1/18	15.60
4/1/18	15.80
5/1/18	16.20
6/1/18	16.30
7/1/18	15.40
8/1/18	15.90
9/1/18	16.70
10/1/18	17.40
11/1/18	17.00
12/1/18	16.40
1/1/19	16.60
2/1/19	16.80
3/1/19	17.50
4/1/19	17.70
5/1/19	18.00
6/1/19	18.10
7/1/19	18.70

8/1/14	24.10
9/1/14	25.70
10/1/14	24.90
11/1/14	23.00
12/1/14	20.40
1/1/15	17.60
2/1/15	16.80
3/1/15	16.60
4/1/15	16.50
5/1/15	16.70
6/1/15	16.90
7/1/15	16.60
8/1/15	16.70
9/1/15	17.50
10/1/15	17.70
11/1/15	18.20
12/1/15	17.20

8/1/19	18.90
9/1/19	19.30
10/1/19	19.90
11/1/19	21.00
12/1/19	20.70
1/1/20	19.60
2/1/20	18.90
3/1/20	18.00
4/1/20	14.40
5/1/20	13.60
6/1/20	18.10
7/1/20	20.50
8/1/20	18.80
9/1/20	17.90
10/1/20	20.20
11/1/20	21.30

Listed in Table 2, summary statistics are included for the monthly fluid milk prices per cwt received by producers during the period evaluated. Compared to January 2020 through November 2020, four months (March, April, May, and September) fell below the median and mean found in the summary statistics. The standard deviation calculated indicates that there is notable variability in the prices that milk producers' experiences in the market. The prices collected in May 2020 represent the minimum for the entire data set. The maximum recorded occurred in September 2014.

Table 2. *Summary Statistics: Monthly Fluid Milk Prices Received, $/cwt*

	Entire Time Period	**Pre-Pandemic Time Period**	**Post-Pandemic Time Period**
Median	18.100	18.000	18.800
Mean	18.669	18.706	18.300
Std Dev	2.586	2.613	2.395
Min	13.600	14.500	13.600
Max	25.700	25.700	21.300

2. METHODOLOGY

The development of the counterfactual model to forecast the lost revenue by the United States dairy producers due to COVID-19 pandemic was conducted using models and calculations performed using Microsoft Excel. First, a training dataset of U.S. dairy prices prior to the COVID-19 pandemic was used to determine stationary/nonstationary property of the dairy price data. Dickey Fuller (DF) test was performed to determine this property of data. Based on the results from the DF test, next an autoregressive moving average (or autoregressive integrated moving average) model is developed with the appropriate lag length. Next, this model is validated for forecasts of out-of-sample forecasts using the measure, mean absolute percent error (MAPE). Once validated, U.S. dairy prices are forecasted for the COVID-19 period (the event under consideration of this study), which is the counterfactual forecasts. Finally, based on the counterfactual prices and observed prices during the COVID-19 pandemic, the price differential occurred due to COVID-19 pandemic is calculated. Ultimately, the loss in revenue to dairy industry is calculated using the price differential for each time period and the dairy production during the pandemic.

To calculate the revenue lost by the dairy industry from March 2020 through December 2020 and quantify the impact of COVID-19 on the fluid milk prices, we forecasted the producers' selling price of milk with an autoregressive integrated moving average (ARIMA) statistical model. This model was selected since the data was determined to be non-stationary through the use of a Dickey-Fuller Test. The t-statistic was calculated to be -2.215 which is larger than the critical value -2.89, 5% cut-off value for the DF test. DF test indicated that the data are non-stationary in levels and permits the use of an ARIMA statistical model. Table 3 contains the summarized results of the Dickey-Fuller Test as well as the results from the hypothesis test. Figure 1 also serves as a physical representation of the conclusions drawn through the Dickey-Fuller Test. In Figure 1, it is clearly seen that the data are non-mean reverting or does not statistically return to the mean price of 18.669 over time. Both of these provide the evidence needed to prove that the ARIMA statistical model is an acceptable model for forecasting U.S. dairy prices.

Table 3. *Results from the Dickey-Fuller Test of Average United States Fluid Milk Prices, January 2011-November 2020*

	Calculated Value; t-Statistic	**Critical Value**	**P-value**	**Results from Hypothesis Test**
U.S. Fluid Milk	-2.215	-2.89	0.029	Fail to reject the null hypothesis that the data are nonstationary in levels

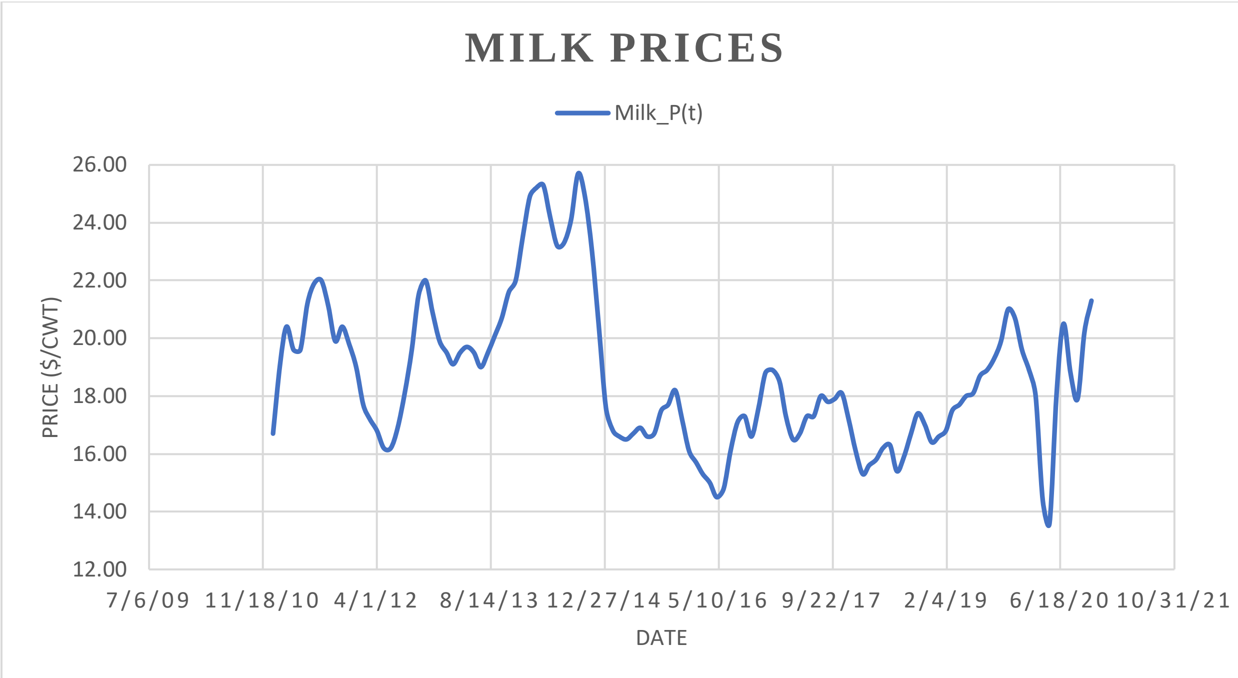

Figure 1. *United States Fluid Milk Prices Received, January 2011 – November 2020*

Following the determination that the data are non-stationary in levels, various conceptual ARIMA models were evaluated using ARIMA(p,d,q). ARIMA models are comprised of three distinct aspects which are mentioned in the acronym. First there is "AR" or autoregression. This aspect of the model observes the dependent relationship between the original observation and the lagged observations. The next parameter is "I" which refers to integration. Data, under this parameter, can either consist of the raw observations or can be differenced to make the time series stationary. Finally, there is "MA" or moving average, the behavior of the error term. Models that utilize moving averages indicated a dependency between the observations and error brought on by a moving average model. The variables listed as "(p,d,q)" are the parameters of the ARIMA model. "p" is the number of lag observations in the model; "d" is the number of differences taken in the model to make the series stationary; "q" is the scope of the moving average.

The general form for the ARIMA model can be represented as follows (Equation 1).

$$\left(1-\gamma_1 B^1-\gamma_2 B^2-\cdots-\gamma_p B^p\right)(1-B)^d P_t=(1-\theta_1 B^1-\theta_2 B^2-\cdots-\theta_q B^q)\varepsilon_t \quad (1)$$

where, p =number of Autoregressive terms, q= number of Moving Average terms,

d = number of differences, B= back shift operator ($B^k P_t = P_{t-k}$).

Testing was implemented to determine which variation of the ARIMA would be used for the final model. The general model for ARIMA(p,d,q) also can be written as follows (equation 2) for deriving ARIMA (1,1,0), ARIMA (2,1,0), ARIMA (3,1,0), and ARIMA (4,1,0).

$$\Delta P_t = \sum_{i=1}^{n} \gamma_i \Delta P_{t-i} + \varepsilon_t \quad (2)$$

where, $i = 1,2,3,4 \ldots . n$

All of these models were all tested in terms of generating the best forecast. Each of these provided a different forecast for the data. However, ARIMA (4,1,0) was determined to provide the best forecast for the data. We found this forecast model to produce the closest fit for the data utilizing a mean absolute percentage error (MAPE). MAPE is a statistical measure that allows us to measure the accuracy of a forecast. Equation 3 shows the general equation for MAPE that was used on all forecasts produced.

$$M = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{P_{t\_hat}-F_t}{P_{t\_hat}}\right| \quad (3)$$

Where M is the mean absolute percentage error, n is the number of summations, P_t is the observed value, and F_t is the forecasted value. Table 4 indicates the data utilized in the MAPE calculation for ARIMA (4,1,0). The second lowest MAPE value corresponded with ARIMA (2,1,0) at 7.7646%.

Table 4. *Results from MAPE Test on ARIMA (4,1,0) Model*

Date	**Forecast P(t_hat)**	**Forecast Error (Abs. Value)**	**Forecast Error/Collected Value (Abs. Value, %)**
1/1/20	19.85416487	0.254164872	1.2968%
2/1/20	19.18242591	0.282425908	1.4943%
3/1/20	18.85959524	0.859595243	4.7755%
4/1/20	17.41903719	3.019037187	20.9655%
5/1/20	12.33496851	1.265031486	9.3017%
6/1/20	15.19457616	2.905423836	16.0521%
7/1/20	20.91551836	0.415518356	2.0269%
8/1/20	19.41353217	0.613532173	3.2635%
9/1/20	17.57243922	0.327560785	1.8299%
10/1/20	18.98732551	1.212674489	6.0033%
11/1/20	21.78077564	0.480775638	2.2572%
		MAPE	**6.2970%**

With the ARIMA (4,1,0) forecast, we produced a counterfactual model that shows the difference between the true and forecasted fluid milk prices from January 2020 to November 2020. Counterfactual models allow researchers to evaluate the cause and effect between observed outcomes and if there had been/not been a change to the market.

From here, we then use this model and the associated price points to determine the difference compared to the actual prices during the COVID-19 pandemic. This summed difference of data points will represent the dollars that were lost in United States fluid milk production from January 2020 through November 2020. Following this calculation, the production total from the fluid milk industry can be multiplied against the difference to determine the total amount of revenue lost in the sale of fluid milk for producers across the United States.

3. RESULTS

Equation 4 and equation 5 demonstrate the model used to determine the appropriate forecast. Equation 4 shows the generic structure for the final forecasting model while equation 5 has the appropriate coefficients applied. The coefficients found in equation 5 were determined with a Microsoft Excel data analysis regression. These models provided the forecasted data points used in the counterfactual model that derived the final results.

$$\hat{Y}_t = \mu + Y_{t-1} + \phi_1(Y_{t-1} - Y_{t-2}) + \phi_2(Y_{t-2} - Y_{t-3}) + \phi_3(Y_{t-3} - Y_{t-4}) + \phi_4(Y_{t-4} - Y_{t-5}) \quad (4)$$

$$\hat{Y}_t = 1.808 + Y_{t-1} + 1.670(Y_{t-1} - Y_{t-2}) - 1.322(Y_{t-2} - Y_{t-3}) + 0.871(Y_{t-3} - Y_{t-4}) - 0.315(Y_{t-4} - Y_{t-5}) \quad (5)$$

Figure 2 and Figure 3 illustrate the true and counterfactual prices for United States fluid milk prices during the COVID-19 pandemic. The ARIMA (4,1,0) forecast contains four lags in the price series. Both figure 2 and figure 3 display the same data; however, figure 3 provides a closer look at the time period from October 2019 to November 2020.

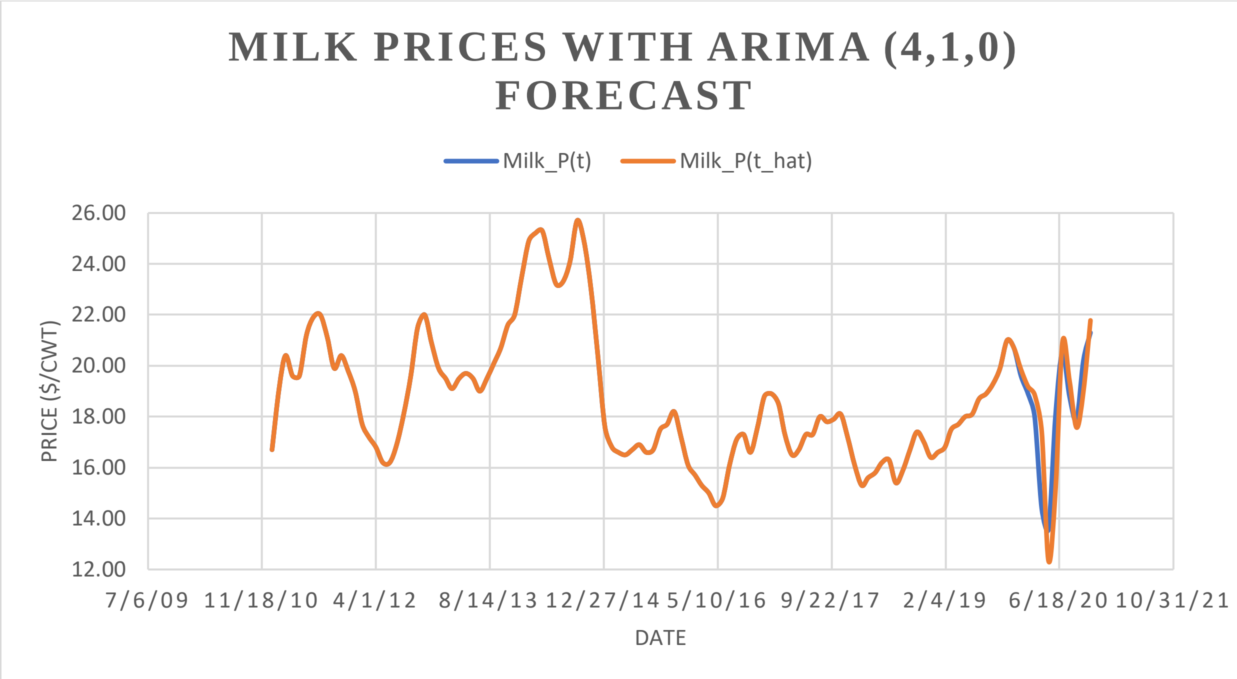

Figure 2. *United States Fluid Milk Prices Received with ARIMA (4,1,0) Forecast, January 2011 – November 2020*

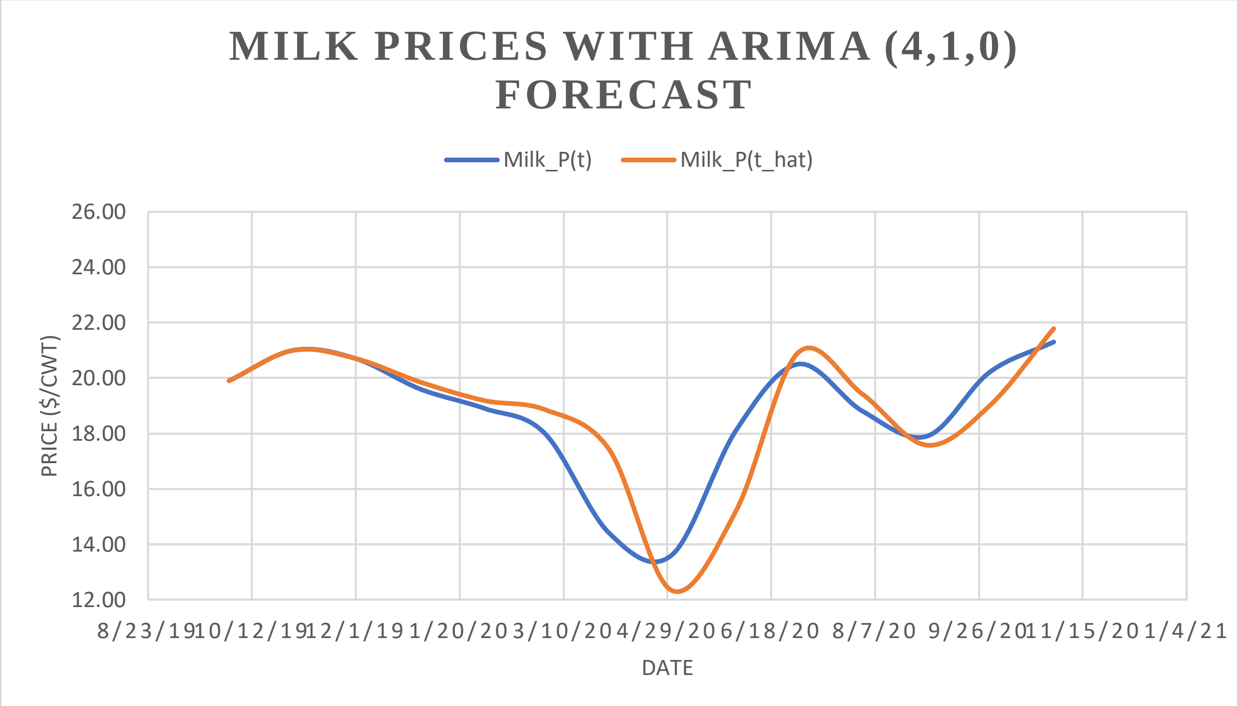

Figure 3. *United States Fluid Milk Prices Received with ARIMA (4,1,0) Forecast, October 2019 – November 2020*

Table 5. Observed and Forecasted Price Data with Difference

Date	Observed Price	Forecasted Price	Difference
1/1/20	19.600	19.854	-0.254
2/1/20	18.900	19.182	-0.282
3/1/20	18.000	18.860	-0.860
4/1/20	14.400	17.419	-3.019
5/1/20	13.600	12.335	1.265
6/1/20	18.100	15.195	2.905
7/1/20	20.500	20.916	-0.416
8/1/20	18.800	19.414	-0.614
9/1/20	17.900	17.572	0.328
10/1/20	20.200	18.987	1.213
11/1/20	21.300	21.781	-0.481
		Total	**-0.21436**

Once the forecast model was produced, it was necessary to compare the forecasted data to the observed data as seen in Table 5. Calculating the area between the two curves in figure 3 indicates that there was approximately a negative difference of $0.21436/ctw from January 2020 to November 2020. This indicates a total decline in the prices that producers saw per hundredweight over the eleven months evaluated. This value was determined from summing the total observed prices and subtracting the summed forecasted prices. The negative difference indicated that money was lost from January 2020 to November 2020.

According to the USDA ERS, the fluid milk supply from January 2020 to November was 194,840 million pounds for the top 24 milk-producing states. 194,840 millions of pounds is equivalent to 1,948,400,000 ctw. Multiplying this supply quantity to the difference between the observed and forecasted prices, we find that $417,656,647.50 was lost by the fluid milk sells on the production side based on this counterfactual model. As more data becomes avaliable to researchers and economists, it is likely that this value could become larger. Furthermore, this could indicate that even more money was lost for milk processesors, distributors, and retailers given that they work with value-added milk products rather than the raw materials. Therefore, more research must be conducted to quantify additional impacts and determine if there were greater losses to the agricultural industry.

This study clearly examined the price discovery patterns of fluid milk data in the United States during the COVID-19 pandemic. When looking toward the specific goals of the study, all objectives were met though the successful application of an ARIMA statistical model and counterfactual model. The results of this research provide the basis for future research. State specific data can now be evaluated to see the impact on the major dairy productng regions and states. Furthermore, this data could be used to evaluate the impact to individual producers.

4. CONCLUSIONS, IMPLICATIONS AND FUTURE WORK

The COVID-19 pandemic has had major implications across the entire agricultural industry. After evaluating the fluid milk prices from January 2011 to November 2020 for the United States as outlined in objective (i), it is better understood the extent that the dairy industry has been impacted and altered. Since 2011, fluid milk prices have been non-stationarity and the uncertainty of the pandemic contributed to this price fluctuation. Using autoregressive integrated moving average (ARIMA) and counterfactual models to achieve objective (ii), we see the forecast of fluid milk prices and the loss of revenue for the United States dairy industry due to the pandemic. Loss to the dairy industry due to COVID-19 pandemic has been significant and amounted to approximately $417,656,647.50.

The dairy industry has seen significant changes over the last several decades. The onset of the COVID-19 pandemic has hurt dairy producers around the country and has caused a significant decline in fluid milk revenue. With nearly a half-trillion dollars being lost in only eleven months, there is high certainty that the United States could see a longer-term impact on dairy producers as they continue to adapt to the pandemic. These impacts may take form in several ways including but not limited to continued consolidation of dairy farms, producers exiting the market, alterations to dairy policy, changes to agricultural emergency relief fund programs, and adjustments to the United States export/import of fluid milk.

As mentioned, there is significantly more research that still needs to be conducted related to the United States' dairy industry. The data found and conclusions drawn in this research setting can now be evaluated regarding state and regional data. This can help state and local leaders make more informed decisions on emergency funds if they are in an area heavily dependent on the dairy industry.

This data can also be expanded to evaluate international data. Milk is a perishable item; therefore, it is typically only exported or imported to countries that are nearby. However, the production of processed milk by-products could be significantly altered because of the impact on fluid milk producers. Shortages of these products should be an issue evaluated in the future. The changes to the industry could have impacts on a multi-national scale. Understanding these impacts could help future trade agreements and maintaining relationships between countries.

Individual producer data will also be important to agricultural insurance companies, farm managers, and policymakers. As more producer information becomes available then better predictions can be made about how suppliers will be responding to the COVID-19 impact. Additionally, insurance companies will be able to determine the impact that they will see as a result of their assistance while producers will be able to better able to allocate their time, energy, and funds to farm operations.

Once this greater understanding unfolds, economists can better quantify the impacts on other forms of dairy. Powdered milk, cheese, ice cream, and other by-products are all major forms of dairy in the United States. Their markets work very differently compared to fluid milk production because of their value-added status. Additionally, these by-products have a different level of necessity and must be evaluated separately.

There is no doubt that more facets of the dairy industry will be impacted other than dairy producers. Dairy cooperatives, processors, transporters, marketers, and retailers will all be impacted by this pandemic. Each of these is a major contributor to the dairy industry and ensures the safe and efficient movement of dairy products from producer to consumer.

It is also likely that there will be impacts and changes to consumer buying preferences if milk prices or supply change too drastically. If there is a shortage or a large price increase, consumers may move away from milk and dairy products. As a response, consumers may make less healthy choices or fail to receive the vital nutrients present in dairy products.

Information regarding the revenue loss in the dairy industry for the United States will be useful to dairy producers, marketers, and policymakers that are responsible for designing national dairy programs. With this analysis, they can better respond and plan for current and future disruptions in the dairy industry. The data collected and evaluated in this research corresponds most closely with elements of macroeconomics. It is possible that this loss of revenue had an impact on the overall gross domestic product (GDP) of the United States. However, this data only provides a starting point for greater microeconomic research as well.

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