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THE EFFECT OF COVID-19 PANDEMIC ON U.S. BEEF EXPORTS TO ITS MAJOR TRADING PARTNERS

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by

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A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
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RESEARCH PAPER APPROVAL

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Approved by:

Dr. Kishore Joseph, Ph.D., Chair

Graduate School

Southern Illinois University Carbondale

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Bien Richard, for the Master of Science degree in Agribusiness Economics, presented on April 10, 2024, at Southern Illinois University Carbondale.

TITLE: THE EFFECT OF COVID-19 PANDEMIC ON U.S. BEEF EXPORTS TO ITS MAJOR TRADING PARTNERS

MAJOR PROFESSOR: Dr. Kishore Joseph, Ph.D.

This study analyzed the effect of COVID-19 on U.S. beef exports to South Korea, Japan, China, Mexico, and Canada between June 2017 and July 2023. After accounting for potential factors influencing exports, the study finds that the pandemic's impact was different in both magnitude and persistence among major trading partners. The drop in exports to Japan and Mexico were notable during the pandemic. The decline in exports began early in the year for Mexico and in March for South Korea. Exports to Canada on the other hand both increased and decreased during this period. Exports to China followed a different pattern and increased during the first six months of the pandemic. Exports to all major export markets recovered as the effects of the pandemic eased by the end of May and fully recovered to pre-pandemic levels by the end of the year. Post-pandemic export volumes have been steady in all major markets amidst the seasonal fluctuations except for Mexico. A confluence of factors including the per capita GDP of the importing country, the exchange rate, trade agreements, time trend, and seasonality influenced U.S. beef exports during the study period. In conclusion, the study reveals the complexity of bilateral trade and importance of accounting for other confounding influences when measuring the impact of the pandemic on U.S. beef exports.

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Lastly, I would love to show appreciation to my parents, Mummy's Court and Oga Jude, for their unconditional love and guidance all my life, and to my brothers and sister and friends at Southern Illinois University (SIU) who made this process whole.

DEDICATION

This paper is dedicated to my parents Oga Jude and Mummy's Court whose unconditional love, discipline and spiritual guidance has made me the man I am today and brought me this far in my career. For the years of sacrifices and selflessness, I am deeply grateful.

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CHAPTER 1

INTRODUCTION

COVID-19) was officially declared a pandemic by the World health Organization (WHO)(Stannard, 2020). The pandemic affected everyday life as we have come to know it. With the first case of COVID-19 emerging in December 2019 in Wuhan China (Maxmen, 2021), there had been 43,341,451 confirmed cases and 1157,509 deaths around the world as of October 25,2020 (WHO 2020). The pandemic spread across the globe, and resulted in a halt to personal activities, business, and international trade causing drastic impact on the masses.

One of the industries severely affected by the global pandemic was the United States (U.S.) beef industry. The U.S. is the world's leading producer of beef, (UDSA: FAO), the second-largest importer, and the third-largest exporter by volume. (U.S. Census Bureau Trade Data - BICO HS-10). COVID-19 caused significant disruption throughout the U.S. beef supply chain, affecting food production, processing, distribution, and consumption. From an export market perspective, maintaining a sufficient workforce to meet production demands during outbreaks while adhering to appropriate social distancing protocols became a challenge to the beef industry. In addition, governments around the world imposed significant restrictions on the movement of goods and labor by restricting transportation by land, sea, and air. Container shipping companies discontinued services leading to lockdowns, port congestion, and cargo handling delays, further weakening maritime supply chains and trade (Guerrero, Letrouit, and Pais-Montes, 2022).

While several studies have explored the disruption caused to the U.S. domestic beef markets during the pandemic, only a few investigate its effect on beef exports. A study by Mallory (2021) identified short term disruptions in beef exports during the pandemic reducing exports by 30% i.e., a reduction in 79 million lbs. of beef. While beef exports dropped sharply in

May and June of 2020, they recovered quickly by July (Peel, 2021). As noted by Baltagas and Cooper (2021), the pandemic affected global trade reducing U.S. meat exports causing downward pressure on U.S. meat. While these studies investigate aggregate beef exports, not much attention has been paid to U.S. exports at the individual country level. An ex-post analysis using disaggregated export data at the country level will allow us. to evaluate the impact of the pandemic, its persistence, and magnitude for each major trading partner. Considering the importance of beef exports to the U.S. meat industry, this question warrants attention.

This study evaluates the effect of COVID-19 pandemic on the U.S. beef exports to top five trading partners from June 2017 to July 2023. The specific goals of this study are as follows:

1. Evaluate the trends in U.S. beef exports to major trading partners.
2. Analyze the factors that influenced beef exports to top five trading partners.
3. Empirically assess the impact of COVID-19 on beef exports.
4. Inform beef industry participants and policymakers about differentials in U.S beef exports to trading partners during the pandemic.

CHAPTER 2

LITERATURE REVIEW

According to the FAS/USDA 2020, the top ten beef-consuming countries in 2020 were United States, China, European Union, Brazil, India, Argentina, Mexico, Pakistan, Russia, and Japan. In these countries, the per capita consumption exceeds 26 kg per year. In the six highest-ranking countries, per capita consumption exceeded 34 kg/year. Although the order may change from year to year, the same countries have tended to occupy the top six rankings over the past two decades. The per capita consumption of beef in the United States in 2022 was 59.1 Lbs. (USDA, 2021), and it is expected to remain stable or slightly increase by 2027 (OECD/FAO, 2017). Approximately 57% of beef consumed is in the form of ground products (Rabobank, 2014).

The global economy experienced a severe downturn in 2020 due to the coronavirus disease (COVID-19) pandemic, resulting in a 3.2% decline in global gross domestic product (GDP), as reported by the International Monetary Fund (IMF, 2021). The value of U.S. beef and beef product exports fell by 5.5% year-over-year in 2020, due to supply chain issues and difficulties in the foodservice industry caused by the COVID-19 pandemic. Daily processing volumes of beef and pork were down by 40% lower than production in 2019 during the last week of April and beginning May, 2020 (Lusk et al., 2021). The disruptions caused by COVID-19 have led to a historic increase in the spread between livestock and wholesale meat prices. This increase in price differentials has attracted the attention of the U.S. Department of Agriculture and the U.S. Department of Justice launched investigations and civil suits because of concerns regarding the concentration and allegations of anticompetitive behavior. (Jayson Lusk, 2020).

As Lara and Alvarado (2021) noted, the pandemic has led to a shift away from beef toward more affordable animal proteins such as chicken, eggs, beans, lentils, and other plant-based proteins at the household level. In response to the pandemic's severe impact on Mexico's national meat market, major organizations producing beef, pork, and poultry united towards the end of 2020 to establish the Mexico United Animal Protein (México Unido Proteína Animal, MUPA). This initiative aims to promote agriculture, industry, and domestic meat consumption as well as position Mexico internationally as a high-quality meat supplier (Gobierno de México, 2020).

With the COVID-19 restrictions in South Korea still in place, consumers became more interested in cooking high-quality red meat at home. Consumer demand for beef is on the rise, and retailers are looking to expand their meat-case offerings. One of the country's largest supermarket chains is attempting to position its meat departments as year-round “steak specialty stores.” (Meat Export Federation of the United States 2022).

The outbreak of the pandemic in Canada and the United States, had a significant impact on the beef industry. Several packing facilities became hotspots for the virus, and were forced to reduce their capacity, leading to a quarter of Alberta's coronavirus cases being traced back to a single meat-packing plant (Rieger 2020). The collapse of beef exports to the United States in April also had a negative impact on the net beef trade balance, dropping to less than one-quarter of that in April 2019 (Statistics Canada, 2020). This reduction in exports was due to the increase in facility shutdowns, labor shortage resulting from ill workers and changes in processing plants processes, (Hobbs, 2021), which reduced American demand for Canadian cattle. Owing to the COVID-19 pandemic, many Chinese manufacturers were forced to close their doors in January 2020. This caused a significant disruption to global supply chains because China is a major supplier of raw materials and intermediate goods to countries all over the world.

COVID-19-related occupancy restrictions in U.S. meat processing plants in the spring of 2020 resulted in cattle remaining in feed yards for longer and fewer conventional cuts available in supermarkets, affecting ranches upstream (Peel et al., 2020; Texas A&M, 2020). The scarcity of conventional beef cuts and volume in supermarkets has led to increased interest among many Americans in the origin and local availability of beef products (Atkins 2020; Emmert 2020; Nagus 2020). Although it is too early to assess the long-term consequences of this trend, investment in alternative regional supply chains may eventually impact the sustainability of conventional grain finishing operations (Hobbs, 2020).

The COVID-19 virus does not pose a direct threat to livestock production; however, the pandemic has had a significant impact on production by causing transportation restrictions and closure of processing plants. In March 2020, when the pandemic was declared in the USA, many beef, pork, and poultry meat packing and processing facilities were compelled to reduce production line speeds or even shut down owing to the spread of COVID-19 among the workforce (Balagtas and Cooper, 2021). President Donald J. Trump issued an Executive Order, putting the American meat industry under the Defense Production Act to keep meat processing facilities open. As of May 2020, approximately 4,200 workers at 115 meat processing plants in the USA had contracted COVID-19 (Campuzano et al., 2020). To prevent the spread of the virus, various restrictions were imposed on plants that remained open. The implementation of these restrictions aimed to keep the facilities operational, with a focus on enhancing sanitation and cleaning measures (Zielińska-Chmielewska et al., 2021). One of the most significant restrictions is the reduction in production line speed, leading to a 45% decrease in processed meat or similar amounts (Cowley, 2020).

CHAPTER 3

DATA

Monthly U.S. beef exports in Metric Ton (MT) and total value of exports in USD for the top five trading partners, South Korea, Japan, China, Mexico, and Canada, from June 2017-July 2023 were collected from the United States Department of agriculture (USDA) - Foreign Agriculture Service (FAS), Global Agricultural Trade System (GATS). The quantity in MT is converted to pounds (lbs.) by multiplying with 2206. 62, and the total value was divided by the quantity to arrive at an imputed export price for each country in $/lb.

Per capita GDP for all five countries was sourced from statista.com, an online source of data and their value was computed by dividing annual GDP by the average annual population sourced from the online source Census.gov. The real exchange rate between the U.S. and other countries was obtained from the USDA Economic Research Service (ERS) data set portal and was provided as local currency per USD. The U.S. cattle Slaughter in 1,000 heads as well as the U.S. retail and wholesale prices in $/lb. were obtained from USDA - ERS data products online service. The global beef price was sourced from the Federal Reserve Bank of St Louis (FRED). The U.S. wholesale beef price is divided by the global beef price to calculate the US-Global beef price ratio.

CHAPTER 4

RESEARCH METHODS

A regression framework with export quantity in each country as the dependent variable and several domestic and foreign variables as the explanatory variables is adopted. The independent variables include U.S. per capita GDP, U.S. cattle slaughter, U.S. retail beef price, U.S. wholesale beef price, the imputed U.S. export price for each country, currency exchange rate, per capita GDP of the importing country, US-Global beef price ratio to account for global competition, interaction terms to account for potential interactions, the COVID-19 impact dummy which is 1 for the first six months of the pandemic and 0 otherwise, dummies representing specific trade agreements between trading partners, monthly dummies to account for potential seasonality and a trend variable accounting for long-term trends. The dummy for trade agreements ($Tagreements_{it}$) varied for each country. The U.S.–Japan Trade Agreement (USJTA) is 0 from June 2017 – December 2019 and 1 thereafter. The dummy variable for China's Phase One trade agreement is 1 from January 2020 to July 2023 and 0 for prior months. The US–China trade war dummy is 1 from July 2018 to December 2019, and 0 otherwise. The US–Mexico-Canda Agreement (USMCA) is 1 from July 2020 till July 2023 and 0 for previous months. The following regression model is estimated using Ordinary Least Squares (OLS):

$$Y_{ijt} = \alpha + \beta_1\, IP_{jt} + \beta_2\, ExcR_{jt} + \beta_3\, GDP_{jt} + \beta_4\, GDP_{it} + \beta_5\, US\_S_{it} + \beta_6\, US\_DPr_{it} + \beta_7\, US\_DPw_{it} + \beta_8\, GBP_{it} + \beta_9\, US\_WrelG_{it} + \beta_{10}\, Covid_{it} + \beta_{11}\, Tagreements_{it} + \beta_{12}\, TrWar_{it} + \beta_{13}\, Trend_{it} + \beta_{14}\, January_{it} + \ldots + \beta_{15}\, November_{it} + \varepsilon_{ijt}.$$

Here,

i = 1, represents US, j = 1,2,3, …5, represents the top five trading partners, and t = 1, …, T, represents time in months. $Y_{ijt}$is the U.S. beef export to the countries (lb.), IP_{jt} is the imputed

export price to each country ($/lb.), $ExcR_{jt}$ is the exchange rate (local currency/$), GDP_{jt} is the per capita GDP of importing countries j ($), GDP_{it} is the per capita GDP of U.S. ($), US_S_{it} is the U.S. cattle slaughter number (in 1,000 heads), US_DPr_{it} is the U.S. retail beef price ($/lb.), US_DPw_{it} is the U.S. wholesale beef price ($/lb.), GBP_{it} is the global beef price ($/lb.), US_WrelG_{it} is the U.S. wholesale price relative to global beef price (U.S. wholesale price/Global beef price), $Covid_{it}$is the dummy variable for COVID-19, $Tagreements_{it}$ is dummy for trade agreement between countries and the US, $Time_{it}$ is the trend term in 1, …., T, $January_{it}$*,…, November*$_{it}$ are dummy variables representing months and ε_{ijt} is the error term. In addition, the interaction of different independent variables such as U.S. cattle slaughter, per capita GDP of county j, Imputed price for country j, with the COVID-19 dummy is also analyzed.

CHAPTER 5

RESULTS

Summary Statistics

Table 1. shows the summary statistics of the variables used in this study. South Korea had the highest average monthly exports of 44,882,607.31 lbs., an average imputed price of 3.58 $/lb., and average per capita GDP of $32,822.94 during the study period. The WON/$ exchange rate has a mean value of 3.58. Japan, the second largest destination for U.S. beef had an average monthly beef export of 46,956,201.38 lbs., a higher average per capita GDP of $38,402.54, and an average YEN/$ exchange rate of 127.64. The imputed price in Japan had a mean value of 2.97 ($/lb.). Beef exports to China averaged 16,163,537.97 lbs. at an average imputed price of 3.92 $/lbs. The YUAN/$ exchange rate has a mean value of 6.89 and an average per capita GDP of $11,061.34. Mexico had an average monthly export of 21,047,420.74 lbs., with a mean imputed price of 3.58 $/lb. Mexico had an average per capita GDP of $10,410.82 and an average PESO/$ exchange rate of 1238.49 during the study period. Canada had an average per capita GDP of $48,860.52, average beef exports of 13,561,719.93 lbs., with an average CAD/$ exchange rate of 1.33.

Table 1. Summary Statistics

		Export quantity (lbs.)	Export value ($)	Imputed price ($/lbs.)	Exchange rate (Local Currency/USD)	GDP per capita ($)
South Korea	Mean	44,882,607.31	162,266,013.72	3.58	1,238.49	32,822.94
	Std. Dev.	7,530,534.69	42,971,162.86	0.49	117.26	1,210.29
	Min.	30,452,636.52	87,833,788.00	2.88	1,078.47	31,600.74
	Max.	63,764,003.80	313,796,636.00	4.92	1,558.12	35,142.26
Japan	Mean	46,956,201.38	139,342,993.34	2.97	127.64	38,402.54
	Std. Dev.	6,555,044.45	22,341,745.89	0.30	19.54	2,702.79
	Min.	33,076,795.71	98,841,406.00	2.55	110.50	33,853.80
	Max.	63,756,287.63	184,596,463.00	3.72	175.08	40,547.98
China	Mean	16,163,537.97	65,261,116.23	3.92	6.89	11,061.34
	Std. Dev.	16,720,366.12	69,569,806.75	0.52	0.42	1,391.99
	Min.	48,501.64	152,215.00	3.12	6.33	8,760.26
	Max.	51,960,688.78	217,088,836.00	6.28	7.99	12,669.60
Mexico	Mean	21,047,420.74	162,266,013.72	3.58	1,238.49	10,410.82
	Std. Dev.	5,622,491.31	42,971,162.86	0.49	117.26	1,328.48
	Min.	5,570,192.89	87,833,788.00	2.88	1,078.47	8,770.02
	Max.	36,088,968.01	313,796,636.00	4.92	1,558.12	13,803.74
Canada	Mean	13,561,719.93	47,642,069.16	3.51	1.33	48,860.52
	Std. Dev.	1,928,681.49	9,261,613.22	0.43	0.05	4,261.19
	Min.	9,630,221.08	30,492,657.00	2.88	1.24	43,383.71
	Max.	18,930,851.48	73,171,990.00	4.51	1.42	55,036.52
		US slaughter (1,000 heads)	**US-Global beef price ratio**	**GDP per capita ($)**		
United States	Mean	2,735.17	1.74	68,072.75		
	Std. Dev.	164.42	0.22	6,510.58		
	Min.	2,189.10	1.33	59,878.72		
	Max.	3,018.90	2.97	80,412.41		

Data from June 2017 - July 2023

Export Volume and Price Trends

South Korea

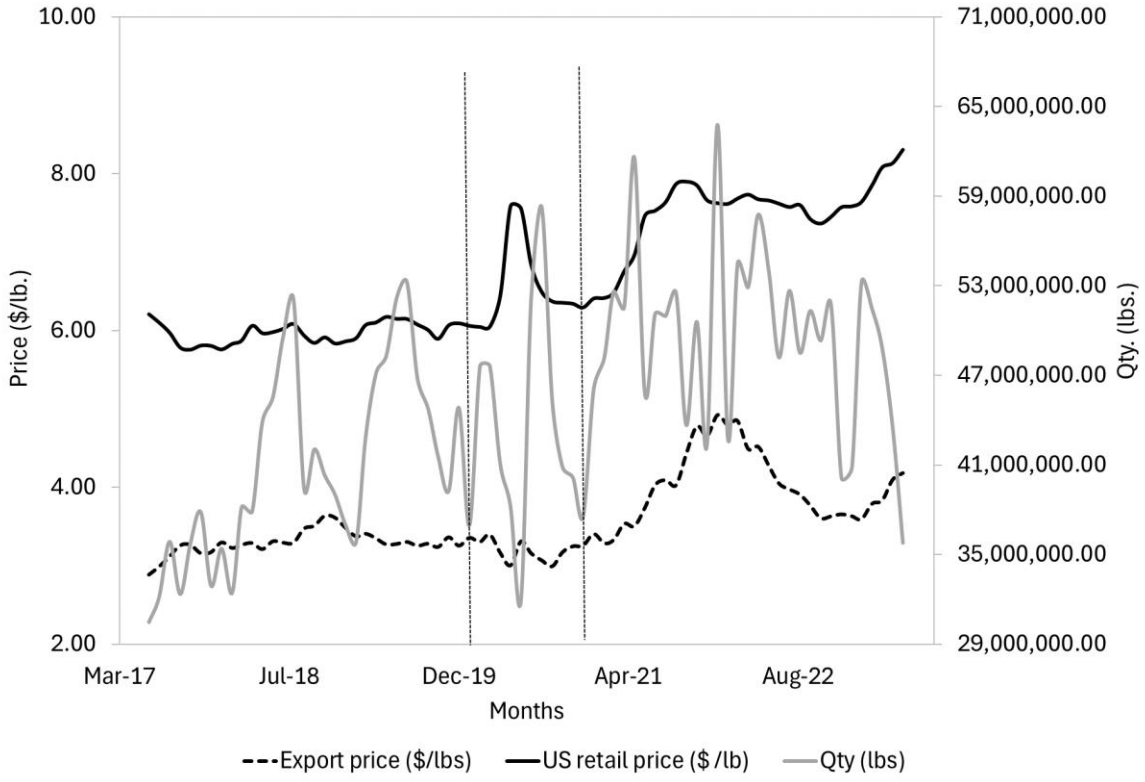

Figure 1. U.S. beef exports to South Korea (June 2017 – July 2023)

U.S. beef exports to South Korea exhibited an increase during the early months of January 2020, peaking at 47.63 million lb. in March 2020, followed by a sharp decline to 31.97 million lb. by June 2020. As seen in Figure 1., the drop in exports started at the beginning of January 2020. However, exports improved from 52.04 million lb. in July 2020 to 58.24 million lb. in August 2020. Through the last quarter of 2020, export volumes continued to fluctuate and declined to 31.96 million by the end of the year. The imputed price of beef showed a decline from $3.40/lb. in March 2020 to $3.00/lb. by May, dropped further to $2.99/lb. in September 2020 as exports improved. Prices steadily increased, from January 2021 at $3.40/lb., reaching

$4.09/lb. by August 2021 and $4.92/lb. by January 2022. Meanwhile, compared to the drop in export quantity during the pandemic, the U.S. retail price for beef was stable at $6.04/lb. during the early months of the pandemic until the second quarter of the year, when it rapidly peaked at $7.56/lb. by June 2020. The retail price then normalized to $6.34/lb. by November 2020 and has been steadily rising since then, reaching an all-time high of $8.3/lb. by July-2023. Beef exports to South Korea showed noticeable fluctuations, featuring periods of growth followed by declines. Beef exports to South Korea have increased 151% (FAS.USDA.2023) in the past decade and the country is the major export destination for U.S. beef after the US-Korea free trade agreement.

Japan

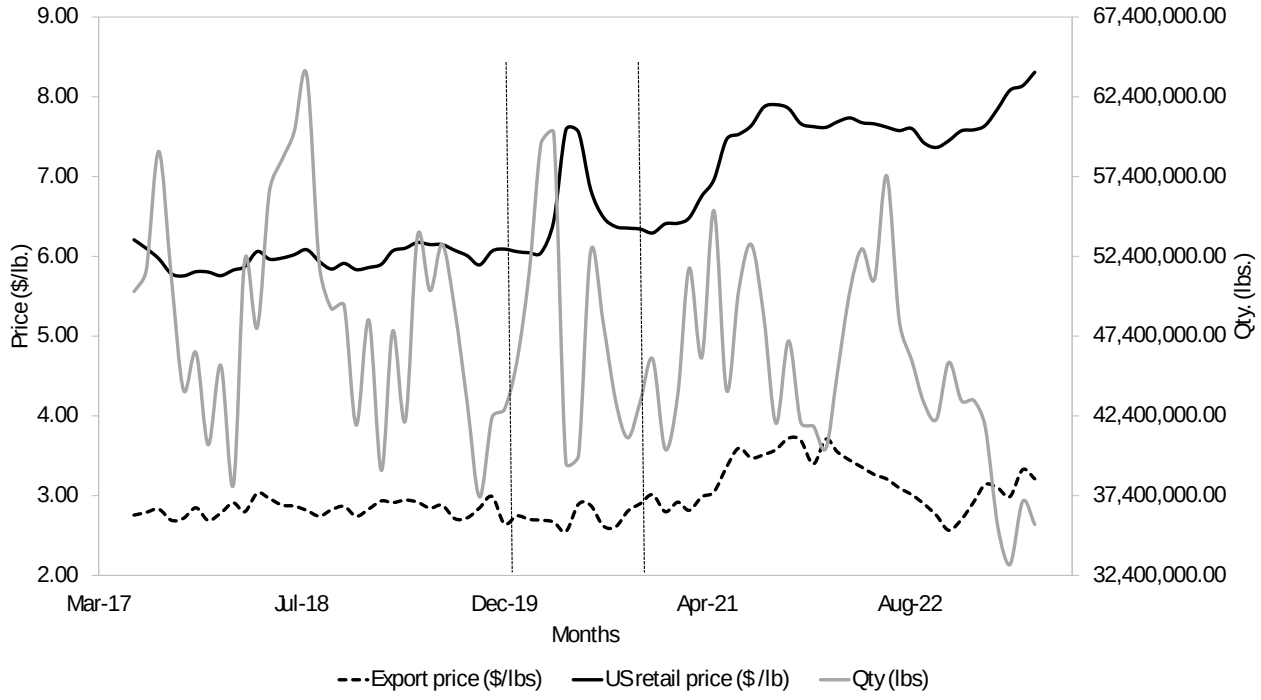

Figure 2. U.S. Beef Exports to Japan (June 2017 – July 2023)

Early months of the pandemic saw a rise in U.S. beef exports to Japan. Export volume rose from 45.79 million lb. in January 2020 to 60.13 million lb. in April,2020. From April 2020, there was a rapid decline in exports from 60.13 million lb. through May to 39.87 million lb. with

further fluctuations through the third and fourth quarter of 2020. As pandemic-related restrictions eased, export volumes continued to fluctuate averaging 43.41 million lb. by the end of the year. Since then, beef exports to Japan have remained unstable with an overall declining trend reaching 35.6million lb. in July 2023. The imputed export price showed a drop from $2.75/lb. in January to $2.55/lb. in May 2020, gradually increased to $2.87/lb. by July, and declined to $2.61/lb. by September. Since then, the price has been on the rise. The U.S. retail price for beef reached a peak of $7.59/lb. by June 2020 and fell to $6.29/lb. by December 2020. Since then, retail prices have continued to climb. The increase in both imputed prices and U.S. retail prices escalated post-pandemic, with domestic beef prices currently following an upward trend, despite fluctuating export volumes since December 2020.

China

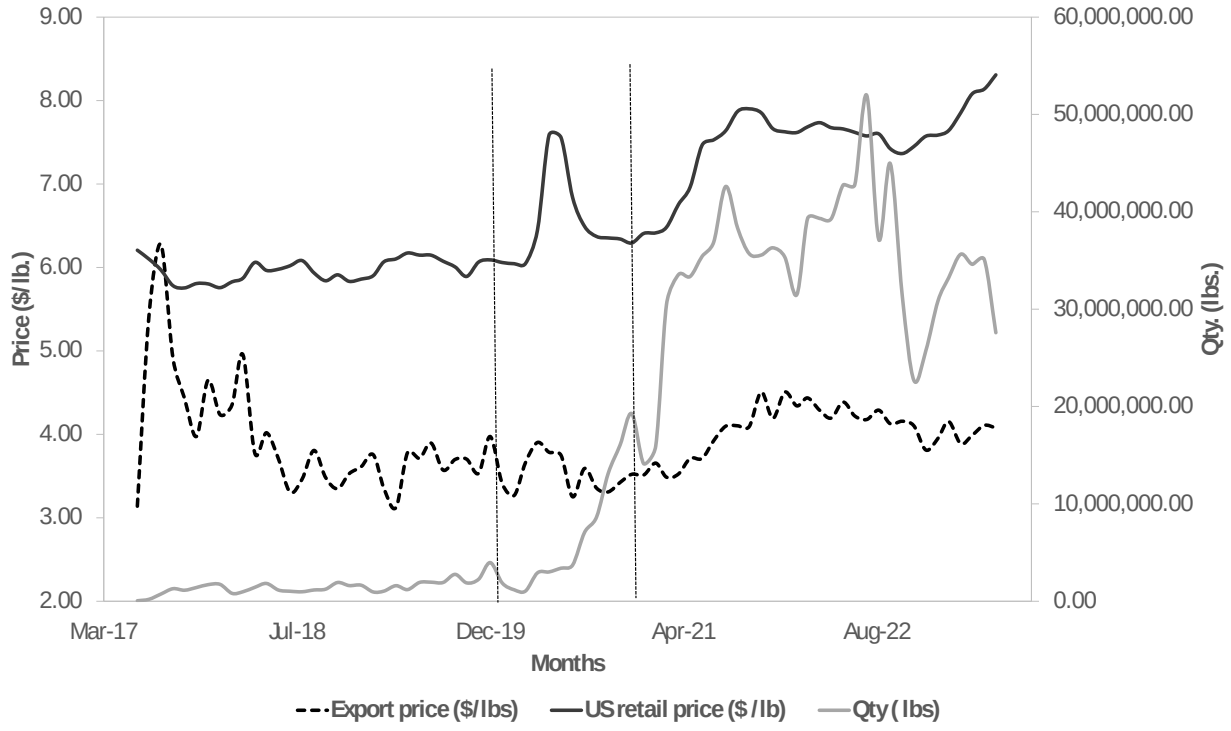

Figure 3. U.S. Beef Exports to China (June 2017 – July 2023)

U.S. beef exports to China rose consistently amid the pandemic. Export volume increased steadily from 1.87 million lb. in January 2020 to 19.27 million lb. in December 2020. Following a decline in January 2021, export volumes climbed steadily to 42.61 million lb. by August 2021. Subsequently, USs beef exports volume to China continued to remain higher than pre-pandemic levels at 27.58 million lb. as of mid-2023. The imputed export rose from $3.27/lb. in February 2020 to $3.90 in April 2020 and gradually stabilized at $4.17/lb. by mid-2023. The U.S. retail price for beef followed a similar pattern, peaking at $7.56/lb. amidst the covid pandemic in June 2020 and decreasing to $6.29 by December 2020. Since then, retail prices have been on the rise, reaching $8.3/lb. by mid-2023. Beef exports to China is on the increase and is due to the US-China Phase one deal which became effective in January 2020.

Mexico

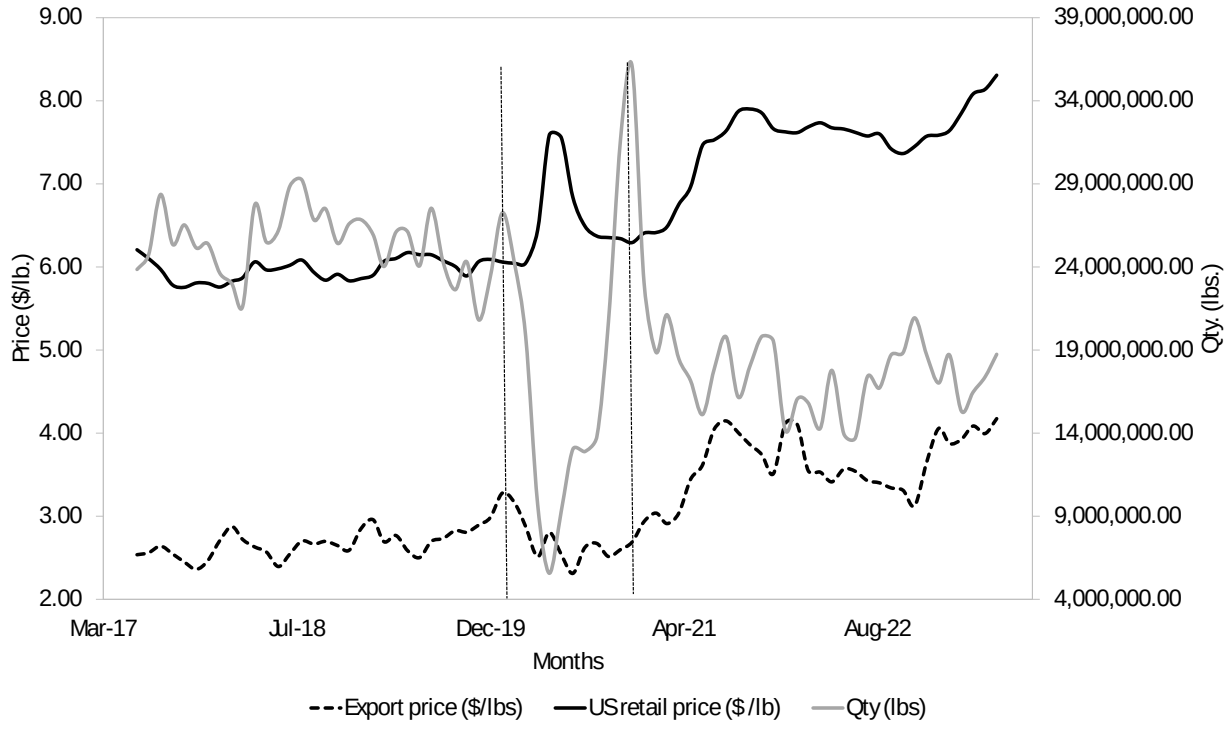

Figure 4. U.S. Beef Exports to Mexico (June 2017 – July 2023)

U.S. beef exports to Mexico showed a significant drop during the early months of the pandemic. Volume declined from 27.3 million lb. in January 2020 to 5.57 million lb. by May 2020. As the initial effects of the pandemic eased, export volumes recovered to 36.1 million lb. by year end. Since then, beef exports to Mexico have fallen and have stabilized around 15-18 million lb. The imputed export price dropped to $2.67/lb. around May 20, increased gradually after the initial effects of the pandemic, and stabilized around $4/lb. by August 2021. Exports to Mexico show a seasonal pattern peaking around the end of the year. Volatility in both imputed prices and U.S. retail prices increased post-pandemic and beef prices currently follow an increasing trend even while export volumes have decreased. The terms of trade between the U.S. and Mexico and the emergence of other dominant players like China in the international meat market may decide what the future holds for U.S. beef exports to our southern neighbor.

Canada

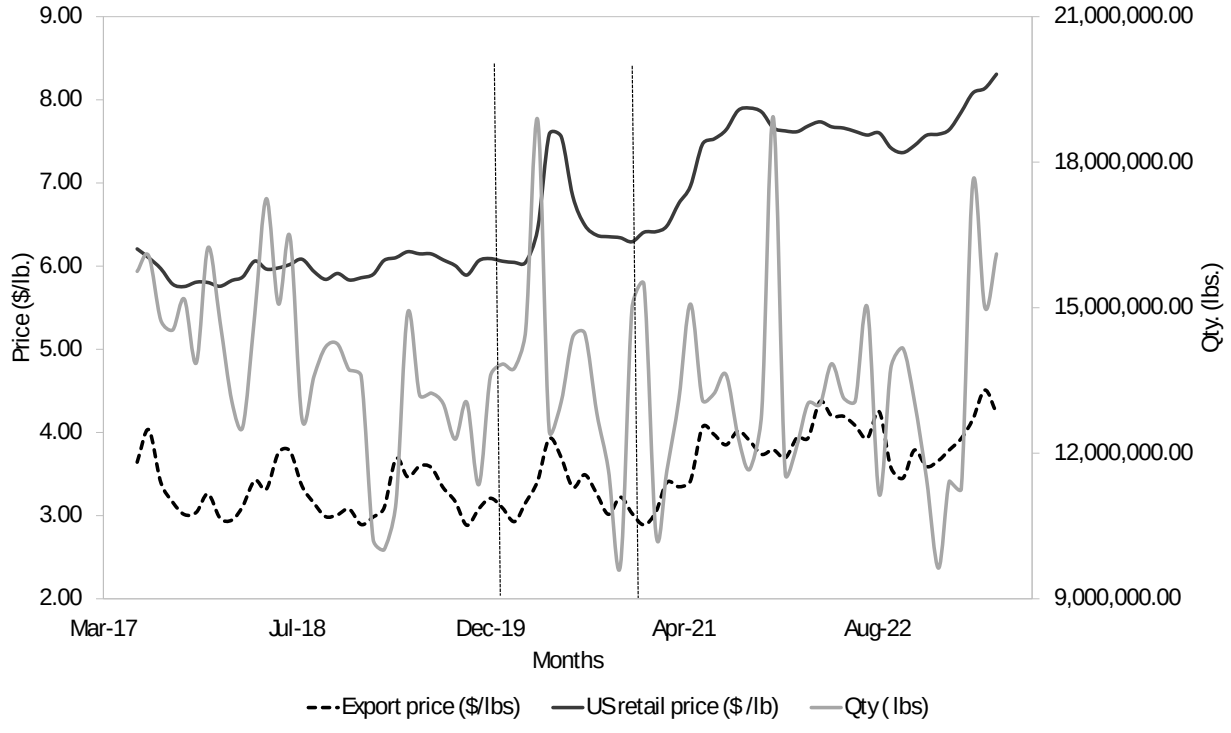

Figure 5. U.S. Beef Exports to Canada (June 2017 – July 2023)

U.S beef exports to Canada was on the rise amidst COVID-19 pandemic all through the first and halfway of the second quarter. With a peak in export volume of 18.87 million lb. in April 2020, we start to see a decline from 12.46 million lb. in May 2020 to 9.68 million lb. in November 2020 before exports started recovering in December at 14.99 million lb. Post covid, export has been stable averaging 13.25million lb. from January 2021 through July 2023 although showing increase in exports during last quarters of the years. The imputed export price followed a similar pattern, rising from $3.09/lb. in January to $3.92/lb. in May 2020. The imputed export price stabilized post covid averaging $3.83/lb. from January 2021 through July 2023. The U.S. retail price for beef displayed a similar trend, peaking at $7.56/lb. by June 2020 and falling to $6.29/lb. in December of the same year. Since then, retail prices have increased, reaching a high value of $8.31/lb. by mid-2023. Exports to Canada showed a seasonal pattern, with volume peaking at the end of the year.

Results of Regression Analysis

Table 2. Regression Results

	South Korea	Japan	China	Mexico	Canada
	Coefficient Est.	**Coefficient Est.**	**Coefficient Est.**	**Coefficient Est.**	**Coefficient Est.**
Intercept	12,494,332.00	11,990,386.00	0.00 ***	79,425,660.00 ***	38,037.62
Covid-19 dummy	-8,820,145.00 *	2,039,944.00	-95,528.58	-5,097,475.00 **	3,205,167.00 ***
Trade agreement dummy		6,257,827.00 *	14,640,555.00 *	-3,715,421.00 **	2,081,416.00 *
Trade war dummy			-202,527.50		
Imputed Price ($/lbs.)	2,066,324.00	1,045,460.00	1,514,531.00	-2,607,964.00 *	
Exchange rate (Local curency./USD)	30,598.77	132,647.00	-8,821,281.00 **	-3,321,126.00 ***	9,024,258.00
Per capita GDP	1,468.21 *	424.97	5,834.37 ***	-2,031.28 ***	228.25 **
US slaughter (1,000 heads)	2,477.39	9,123.41	2,985.56	10,335.21 **	4,845,840.00
US-Global beef price ratio	-7,977,638.00 *	-2,762,310.00	-3,353,840.00	4,197,260.00 *	-575,712.80
Per capita GDP US	-1,345.80 *		2,752.98 ***		
Trend	358,666.70 ***	-308,239.60 ***	-616,365.90 **		-103,680.70 **
January	7,521,425.00 *	-121,290.70 *	-16,372,836.00 ***	-2,223,992.00	-2,242,177.00 **
February	5,362,761.00	598,084.40	-14,882,367.00 ***	-865,317.30	-3,989,992.00 ***
March	10,506,254.00 **	4,766,399.00	-10,822,263.00 ***	-3,867,984.00 **	-3,553,848.00 ***
April	9,918,947.00 **	4,228,853.00	-7,238,287.00 *	-3,246,129.00 *	-1,762,443.00 **
May	13,147,193.00 ***	5,566,991.00	-5,594,261.00	-4,955,554.00 **	-86,882.29
June	5,521,206.00	1,454,229.00	-3,488,253.00	-7,082,965.00 ***	-1,500,814.00
July	5,561,635.00 *	6,976,667.00 *	-3,738,101.00	-4,026,658.00 **	-567,638.20
August	8,821,985.00 **	7,448,039.00 *	735,453.30	-4,720,831.00 **	-1,484,660.00
September	2,799,030.00	2,901,768.00	-424,868.20	-4,804,542.00 ***	-2,495,792.00 **
October	285,253.70	-3,116,774.00	1,657,957.00	-3,895,331.00 **	-2,056,026.00 **
November	1,223,658.00	489,713.20	683,064.70	-2,342,599.00	-2,465,325.00 **
R^2	0.59	0.49	0.94	0.79	0.45
AIC value	34.14	34.07	33.85	32.85	31.68
N	74	74	74	74	74

Notes: *** significant at α=0.01, ** significant at α=0.05, * significant at α=0.10. Model choice was based on higher R^2 and the lowest AIC value.
Data used is from June 2017 - July 2023

South Korea

The results for South Korea are available in Table 2. The regression model has an R^2 of 0.59 and an Akaike Information Criterion (AIC) value of 34.14. The variance inflation factor (VIF) for all variables is lower than 10 with the exception of US per capita GDP which has a value of 45. The COVID-19 dummy is statistically significant at $\alpha = 0.10$ and has a negative sign showing that the pandemic had a significant effect on the U.S. exports to South Korea after accounting for seasonality and trend. The trend variable and the monthly dummy variable for May are statistically significant at $\alpha = 0.01$. The per capita GDP of South Korea, per capita GDP of U.S., and the US-Global beef price ratio are significant at $\alpha = 0.10$. The imputed price for South Korea, the WON/$ exchange rate, and the U.S. cattle slaughter variables were not statistically significant.

The positive sign of the South Korean per capita GDP is reassuring and corroborates the strong demand for U.S. beef due to increased domestic demand from Korea. The trend term is significant and positive supporting the gradual, but consistent rise in U.S. beef exports to South Korea. The dummy variable for May, the South Korean "Family Month" has a positive sign reflecting the peak consumption of beef in South Korea during this month and reflecting seasonality in exports. Based on the results, we can conclude that COVID-19 pandemic had a considerable impact on U.S. beef exports to South Korea, but the effect was small, and exports recovered within a month.

Japan

The regression model for Japan presented in Table 2. has an R^2 of 0.49 and an AIC value of 34.07. All the variables in the model have a VIF less than 10, indicating no multicollinearity issues. The dummy variable for COVID-19 for Japan is not statistically significant but has a positive coefficient. U.S. beef exports to Japan were on the rise in early 2020 and dropped by

March, rising again by May, which may explain the positive sign of the coefficient. The trade agreement dummy was significant at $\alpha = 0.01$. The imputed price, Japanese per capita GDP, U.S. per capita GDP, U.S cattle slaughter, and US-Global price ratio were not significant at $\alpha = 0.10$. The dummy variables for July and August are positive and significant at an $\alpha = 0.10$ reflecting the seasonality in exports. The increase in export demand is consistent with higher demand for beef from Japanese beef serving food service restaurants in July and August. The dummy variable for January is also statistically significant, but negative showing a higher demand for beef in Japan during December. It can be concluded that while COVID-19 did not influence U.S. beef exports to Japan.

China

The regression model for China has an R^2 of 0.94 and an AIC value of 33.85 and is presented in Table 2. VIF values for all variables are under ten with the exception to the trend dummy indicating no serious multicollinearity issues. The COVID-19 dummy for China is not statistically significant at $\alpha = 0.10$ and has a negative sign. The Chinese per capita GDP, U.S. per capita GDP, and monthly dummies for January, February, and March are positive and significant at $\alpha = 0.01$. The YUAN/$ exchange rate and the trend variable are significant at $\alpha = 0.05$ and the trade agreement dummy and monthly dummy for April are significant at $\alpha = 0.10$. The trade war dummy, the imputed export price, U.S. price-global price ratio, and the U.S. Slaughter are not significant at $\alpha = 0.10$. The coefficient of per capita GDP of China has a positive sign revealing that the rising income among Chinese citizens have a positive effect on U.S. beef exports. Moreover, the trade agreement dummy has a positive coefficient showing it had a positive effect on U.S. beef exports to China. Based on the results, we can conclude that COVID-19 pandemic

did not have detrimental effect on U.S. beef exports to China. On the contrary exports increased during the first six months of the pandemic.

Mexico

The results of the analysis of U.S. exports to Mexico are available in Table 2. The estimated model has an R^2 of 0.79 and an AIC value of 32.85. The Variance Influence Factor (VIF) for all variables was less than 10 confirming no multicollinearity issues. The COVID-19 dummy variable is significant at an $\alpha = 0.05$, with a negative sign, reflecting the drop in exports during the first few months of the pandemic. The per capita GDP of Mexico and the PESO/$ exchange rate are statistically significant at $\alpha = 0.01$. The imputed export price, U.S. cattle slaughter and the USMCA dummy are significant at $\alpha = 0.05$. Moreover, the US-Global beef ratio is significant at $\alpha = 0.10$.

Exports appear to decrease with a higher imputed export price as expected. The PESO/$ exchange rate has a negative sign indicating that exports decrease as the U.S. currency appreciates. An increase in cattle slaughter is found to have a positive effect on beef exports to Mexico. Several monthly dummy variables are statistically significant indicating potential seasonality in U.S. exports to Mexico. The US-Global beef price ratio showed a positive sign signifying that U.S. exports to Mexico increased even when U.S. prices were high compared to other major exporting countries around the world. The export volume is found to decrease with an increase in the Mexican Per capita GDP and has decreased following USMCA which was unexpected. Based on these results, we can conclude that exports to Mexico responded to economic forces and were affected during the early months of the pandemic. These effects, though intense, were short-lived, as export volumes recovered by the end of 2020.

Canada

The results for analysis for Canada are available in Table 2. The regression model has an R^2 of 0.45 with an AIC value of 31.68. The VIF for all variables in the model is less than 10 except for the trend dummy. The COVID-19 dummy is significant at $\alpha = 0.01$. The dummy variable for the US-CANADA Free Trade Agreement and per capita GDP for Canada are significant at $\alpha = 0.05$. The CAD/$ exchange rate , U.S cattle slaughter, US-Global beef price ratio are not statistically significant. U.S. beef exports to Canada were on the rise in early 2020 which dropped in April only to rise again in May which may explain the positive sign of the coefficient for COVID-19 dummy. The United States Mexico Canada Agreement (USMCA) dummy is positive and shows increased beef exports following the trade agreement. The trend term is significant at $\alpha = 0.05$ with a negative sign showing a gradual decline in U.S. beef exports to Canda over time even amidst occasional jumps in exports. Most of the monthly dummies were significant with a negative sign except for May, June, July, and August, reflecting the seasonal demand for U.S. beef in Canada. As such we can conclude that, COVID-19 influenced U.S. beef exports to Canada, but the effect was short-lived.

CHAPTER 6

CONCLUSIONS

This study analyzes the effect of the COVID-19 pandemic on U.S. beef exports to South Korea, Japan, China, Mexico, and Canada during the 2017-2023 period. After accounting for several factors that could influence exports during this period, we conclude that the impact of the pandemic was different among the major trading partners.

The pandemic did not create considerable impact in the popular U.S. beef destination of Japan, while it affected exports to South Korea, Mexico, and Canada. U.S. beef exports to South Korea, another popular destination for U.S. beef decreased during the pandemic. U.S. beef exports to Mexico dropped during the first six months of the pandemic and exports to Canada both increased and decreased during this period. Exports to China on the other hand increased consistently in the early months of the pandemic which may be attributed to the US-China Phase One agreement which came into effect on January 15, 2020. U.S. beef exports were increasing in South Korea, Japan, and Canada during the early months of 2020. The decline in exports in these markets began only between March and April. Whereas the decline in exports to Mexico started by January 2020. The magnitude of the drop in exports were large in South Korea and Mexico. Exports to all major export markets recovered as the effects of the pandemic eased by the end of May. Post-pandemic export volumes have been steady in all major markets amidst the seasonal fluctuations except for Mexico. The changing terms of trade with U.S. post-USMCA, the emergence of China as a major importer of U.S. beef, and the strength of the U.S. dollar are the most likely reasons for this declining trend.

This research contributes to existing work on COVID-19 effects on agricultural markets by providing a snapshot of U.S. beef exports to the top five export destinations. The results from

this impact study will help policymakers and industry stakeholders understand the complex nature of bilateral trade and the confluence of economic factors that influence it.

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