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Abstract

This study examines the impact of retaliatory tariffs imposed on U.S. pork, soybeans, corn and wheat by China and on U.S. pork by Mexico on select U.S. agricultural commodities. Results show a decline in U.S. exports by 32% for pork and corn, 15% for soybeans, and 1.5% for wheat relative to the baseline. Domestic pork prices fall by 12% while crop prices decrease by between 8% and 12%. In the long run, the decline in U.S. production leads to 60,000 fewer jobs and $3.1 billion less labor income. The economy experiences a loss of almost $12 billion in national output.

Key words: agricultural markets, retaliatory tariffs, trade war China-U.S.A

JEL Classification: F140, F170, Q170, Q180

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Resumen

Este trabajo examina el impacto en algunos commodities de EEUU de los aranceles impuestos a modo de represalia sobre sus exportaciones de carne de cerdo, soja, maíz y trigo por China y de carne de cerdo por México. Los resultados muestras una reducción en las exportaciones de EEUU de 32% para carne de cerdo y maíz, de 15% para soja, y de 1.5% para trigo en relación al escenario base (sin aumento de aranceles). Los precios domésticos de cerdos se reducen en 12%, mientras que los de los cultivos lo hacen entre 8% y 12%. En el largo plazo, la reducción en la producción en EEUU resulta en 60,000 menos puestos de trabajo y en US$3100 millones menos en términos de ingresos laborales. La economía experimenta una pérdida de casi US$12,000 millones en producción nacional.

Palabras clave: aranceles de represalia, guerra comercial China-EEUU, mercados agropecuarios

Código: F140, F170, Q170, Q180

1. Introduction

China and Mexico are significant net importers of several agricultural commodities, for which the U.S is a major exporter, namely pork, soybeans, corn, and wheat. Thus, policies that curtail the demand for exports from the U.S. to China and Mexico can have large negative domestic economic impacts. In May 2018, the U.S. imposed a 25% tariff on imported steel and a 10% tariff on imported aluminum from all countries including China. However, several countries were "excluded" once they agreed to a quota with the U.S. The Chinese retaliation was immediate, with a long list of (128) products being affected, including agricultural products such as pork and ethanol (Li, Zhang and Hart, 2018; Davis, 2018). Additionally, the U.S. initially imposed 25% tariff on $50 billion worth of imports from China and later, on September 24, 2018, the U.S. imposed a 10% tariff on an additional $200 billion against a new list of Chinese imports. Mexico imposed tariffs on U.S. goods including whiskey, cheese, steel, bourbon and pork while Canada imposed tariffs on $17 billion worth of U.S. products. China imposed up to 25% tariffs on $60 billion worth of U.S. goods, including soybeans.

According to data from the United States Department of Agriculture (USDA), China is by far the largest importer of soybeans in the world, buying roughly 62% of global exports in 2017/18. In the case of pork, China and Mexico imported 20% and 14% of total 2017 exports, respectively. With a smaller market share (roughly 2-3% of global imports in 2018/19), China is also an important player in the global trade of corn and wheat.[1] Given their significance in global trade, changes in the two countries' markets and/or policies have the potential to create significant impacts on global commodity markets. The current tariffs also introduce long-term risks. Brazil has been dominant in the soybean global market as a result of its strong growth in productivity, displacing the U.S. in the Chinese market (Yao, Hertel and Taheripour 2018).

Some of the effects were already evident in the second half of 2018, with China shifting some of its soybean imports away from the U.S. towards Brazil, and soybean from Brazil commanding increasing price premiums relative to the oilseed produced in the U.S. (Zhou et al, 2018; AgriCensus Daily Report, July 2018). Grant, Ning, and Peterson (2018) estimated (micro) trade elasticities that indicate countries' rapid change of trading partners in response to changes in the relative tariff levels. Trade barriers between the U.S. and China can also incentivize the development of improved and lower cost infrastructure in Brazil to potentiate its commercial advantage. To alleviate the short-run negative effects of the Chinese tariff for domestic farmers, the U.S. government announced the introduction of three assistance programs for 2018 (USDA, 2018; Giri, Peterson, and Sharma, 2018) which were expanded in 2019 (USDA, 2019). However, the trade disputes can have long lasting consequences for U.S. producers.

Tariffs disrupt trade and consumption patterns leading to lower domestic prices and production (for countries facing the tariffs), and also result in lower overall welfare and depressed economic activity when compared to a situation without government

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[1] Calculated from trade data obtained from United States Department of Agriculture Production, Supply, and Distribution Database (PSD Online)
https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery

intervention. The main objective of this study is to analyze the impacts of retaliatory tariffs by China and Mexico on U.S. agricultural markets including effects on jobs, incomes, and value added. Impacts on global production and prices for major agricultural commodities are also assessed.

This analysis will quantify some of the impacts on the U.S. economy using two models: a global agricultural modeling system and an input-output model for the U.S. The agricultural model system provides the impact on U.S. and global agricultural commodities in terms of supply, utilization, and prices while the input-output model provides industry-level impacts in terms of changes in employment, labor income, industrial output, and value added. Both models capture the interlinkages among sectors, which is important given that in the interrelations involved in the supply and demand for agricultural products, factors that disrupt the market for one commodity are likely to affect other sectors of the agricultural markets (Yao, Hertel, and Taheripour, 2018).

Impacts of Chinese tariffs on U.S. soybeans, wheat, corn, sorghum, and beef (but not pork) on bilateral and global trade, production and welfare were analyzed by Taheripour and Tyner (2018), using a computable general equilibrium model (GTAP-BIO). Using a partial equilibrium model, Zheng et al. (2018) considered Chinese retaliatory tariffs on soybeans, cotton, sorghum and pork (but not on corn, and wheat). Table 1 compares the results of this study with the results presented by Taheripour and Tyner (2018), and by Zheng et al. (2018). It is important to note that these results are not directly comparable as modeling frameworks differ between the studies, and there are variations in terms of the commodities being targeted and in terms of the countries imposing the tariffs. However, the comparison does provide some insight on the range of impacts based on model structure.

None of the aforementioned studies consider the implications of the simultaneous tariffs imposed by Mexico on U.S. pork. Non-equilibrium approaches were also used to assess impacts on U.S. soybean exports as a result of retaliatory tariffs on soybeans imposed by China (Muhammad and Smith, 2018). General equilibrium strategies have to assume the policy is extended through time and look at the long-run implications, without informing the short run. Given the importance of the topic in terms of the potential economic implications for both the short and long terms, additional work and a better understanding is warranted. This study attempts to do that.

The paper is organized as follows: the next section describes the methodology used and the changes to the CARD/FAPRI model specification made in order to capture the spatial dimension of the free trade agreement. Section 3 outlines the scenario assumptions and reports the short-run and long-run market impacts of the retaliatory tariffs by commodity from the two models. Concluding remarks are presented in the final section.

Table 1. Comparison of results from studies imposing tariffs on different commodities and countries and using different modeling frameworks

	Taheripour and Tyner (2018)[*]	Zheng, Wood, Wang, and Jones (2018)[**]	This study	
Type of Model	CGE	PE[*]	Multimarket-partial equilibrium	
Time frame	Long run	Short run (one year)	Short run	Long run
		% Change relative to a baseline		
Trade				
US soybean exports	-24.1 – -34.2	-	-16.4	-15.2
US soybean exports to China	-47.7 – -90.6	-34.2	-62.2	-61.5
Total soybean trade	-0.2 – -2.5	-	-10.9	-10.5
US Pork exports	-	-	-29.8	-31.9
US pork exports to China	-	-83.3	-88.7[***]	89.1[***]
US Production				
Soybeans	-10.6 – -14.7	-1.6	-2.7	-2.3
Wheat	1.9 – 2.9	-	1.1	0.2
Corn	NA	-	-1.57	-4.8
Grains	1.2 – 1.7	-		
Pork	NA	-0.2	-1.47	-3.3
Price				
Soybeans	-4 – -5	-3.9	-9.7	-11.8
Wheat	-	-	-3.5	-8.1
Corn	-	-	-4.9	-8.9
Pork	-	-0.6	-11.6	-11.7

[*]Tariffs on soybeans, wheat, corn, and beef, [**] Tariffs on soybeans, cotton, sorghum and pork, [***]US exports to China and Mexico combined.


2. Methodology

This analysis uses two models: the CARD/FAPRI agricultural modeling system and the IMPLAN model.[2] The CARD/FAPRI model is a system of econometric, partial equilibrium, non-spatial models of global agriculture. The models cover all major temperate crops, sugar, biofuels, dairy, and livestock and meat products for all major producing and consuming countries. Extensive market linkages exist in the modeling system, reflecting derived demand for feed in livestock and dairy sectors, competition for land in production, and consumer substitution possibilities for close substitutes such as vegetable oils and meat types (figure 1a).[3]

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[2] CARD stands for the Center for Agricultural and Rural Development at Iowa State University; FAPRI stands for the Food and Agricultural Policy Research Institute at Iowa State University; and IMPLAN stands for IMpact Analysis for PLANing.

[3] More detailed commodity model descriptions of the CARD/FAPRI agricultural modeling system are available in http://www.fapri.iastate.edu/models/.

The interlinked models are used to generate five to ten-year baseline projections for agricultural markets and for policy analysis based on the baseline projections. The CARD/FAPRI agricultural modeling system has been used in various studies to analyze the impact of various policies and shocks on agricultural markets and has been described in detail in previous peer-reviewed publications (Carriquiry et al., 2019; Hayes et al., 2009; Searchinger et al., 2008).

Figure 1a: CARD/FAPRI Model Interactions
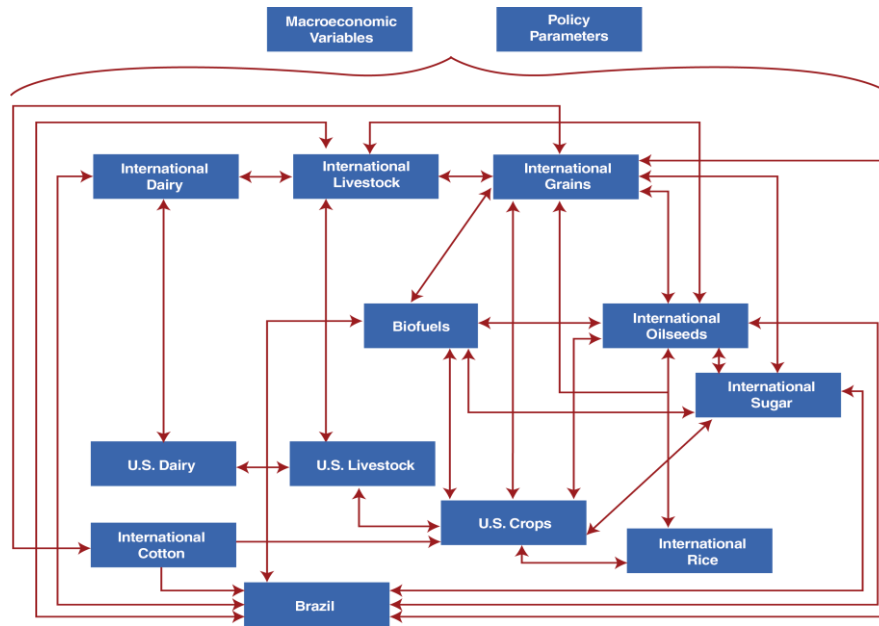
The IMPLAN input-output model is an inter-industrial accounting system that produces input-output accounts by region (figure 1b). It is populated with data that are updated annually and is used to estimate the economic impacts of changes in regional production. Input-output models are price-static models that rely on economic characteristics of the recent past to project near-term outcomes. Modifications were made to the national model to more adequately reflect the crop and animal production sectors measured for this analysis.

Figure 1b: IMPLAN Model Outline
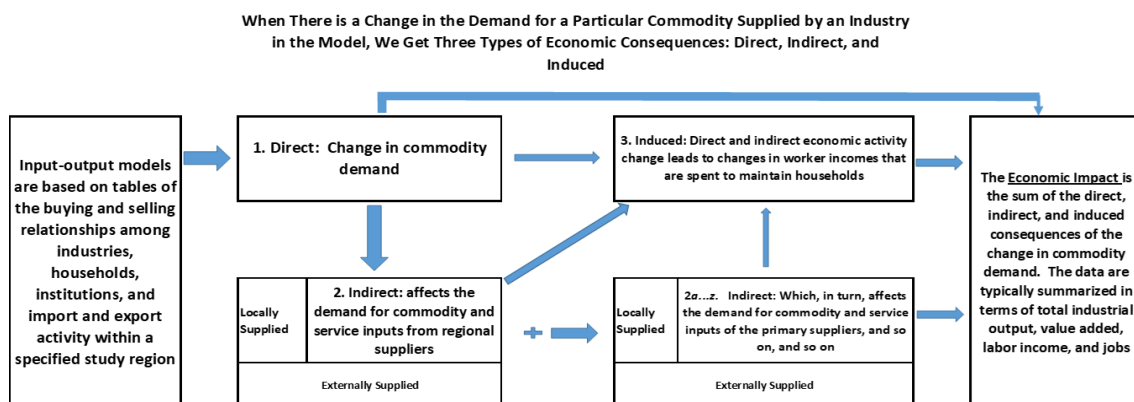
For this analysis, the agricultural models are first run in a business-as-usual mode, which we label the "base case" or "baseline". Then the modeling system is modified to simulate a scenario in which the retaliatory tariffs are imposed on the U.S. by China and Mexico for a specified set of commodities (pork, corn, wheat and soybeans for China; pork for Mexico). After the changes, the modeling system is run again and a new global agricultural market equilibrium is obtained. This new equilibrium is labeled the "scenario". By comparing this scenario against the base case, we estimate the impacts of the specific tariffs on U.S. agricultural markets and on global markets. Output from the CARD/FAPRI model is then used as input into the IMPLAN model.

The IMPLAN model translates percentage changes in the quantities produced of the targeted commodities into standard economic impact summarizations. The current national model is modified to explicitly include the agricultural and manufactured commodities specified in this study. Percentage changes in output in the relevant commodity sectors generated by the CARD/FAPRI model are used to shock the model and produce multiplied-through impacts in terms of the direct effects on a particular industry or commodity, the indirect effects upon supply chains, and the induced effects caused by changes in labor income and household consumption. These effects are reported in terms of industrial output changes, value added changes (which is analogous to Gross Domestic Product or GDP), labor income consequences, and job impacts.

CARD/FAPRI Model Modifications

The CARD/FAPRI agricultural modeling system is non-spatial in specification and therefore, bilateral trade between countries is not tracked directly. The modeling system solves for world reference prices using a single world market-clearing mechanism that equalize net imports and net exports without regard to sources of imports and destinations of exports. This poses a challenge when analyzing bilateral or regional trade especially given that the U.S. price is considered the world reference price in many of the modeled commodities. This price is transmitted to all the countries in the evolution of their respective domestic prices, which drive their demand and supply situation.

Since the retaliatory tariffs are imposed on the U.S. by two countries, the standard CARD/FAPRI single market clearing condition to determine a world price is augmented to introduce some spatial dimension that captures differential price signals resulting from the retaliatory tariffs on U.S. exports by China and Mexico. We discuss these adjustments in some detail here because we believe it is the first time a partial equilibrium displacement model has been used to evaluate a bilateral trade dispute.

The retaliatory tariff scenario is implemented in the modeling system first by imposing the tariff on each commodity by country thus imposing border protection for products imported from the U.S. by China and Mexico. Additional equations are introduced into the modeling system for the affected commodities to separate trade flows between the countries affected by tariffs from trade with other commercial partners. In short, trade from tariffed products are separated from trade not subjected to tariffs.

We introduce the following additional specification to implement the necessary model augmentation:

a.　　Since the U.S. is the world reference price in the case of pork, soybeans, corn, and wheat, we introduce a new world price where only trade of the U.S. and China or the U.S. and Mexico with other countries is accounted for together with the trade of all other countries.

b.　　We ensure that the domestic price evolution in China and Mexico for all relevant commodities is driven by a price transmission that is reflecting price changes in the U.S. market.

c.　　The historical shares of the U.S. in the imports of China and Mexico are determined using data provided by the USDA Foreign Agriculture Service GAIN Reports. An equation projecting the share of the U.S. in the Chinese and Mexican import markets, respectively, is added to allow for the disaggregation of Chinese and Mexican imports by origin, that is, Chinese and Mexican imports sourced from the U.S. and imports sourced from all other countries.

d.　　A mirror spatial dimension is added in the U.S. model. That is, total U.S. exports are disaggregated into exports to China and Mexico, respectively, and exports to all the other countries. To balance the two markets, we impose by construction that U.S. exports to China or Mexico are equal to the Chinese or Mexican imports from the U.S., respectively. U.S. exports to all other countries are specified with a behavioral equation driven by the price in the domestic market relative to the price in the world.

e.　　The China country model and the Mexico country model each have a price transmission from U.S. prices with trade as a residual to balance the domestic market. The U.S. on the other hand, has a market-clearing price determination with trade to all other countries, except China and Mexico, which is represented by a behavioral equation.

f.　　The equilibrium in the rest of the world excludes the intra-trade between U.S. and China, and between U.S. and Mexico, and solves for a market-clearing world price. This world price relative to the domestic U.S. price drives the trade of the U.S. to other countries.

3. Scenario Assumptions and Results

This section presents the scenario reflecting the imposition of retaliatory tariffs by China and Mexico on a set of U.S.-produced agricultural commodities and describes the main results of the modeling analysis performed. We begin with a description of the scenarios and the expected short-run and long-run impacts on domestic markets for select agricultural commodities. Some global implications of the retaliatory tariffs considered are then highlighted. We use the augmented version of the CARD/FAPRI modeling system of global agriculture described previously to guide this analysis. We then present important findings in terms of impacts on the U.S. economy, including direct, indirect and induced results, with special consideration to implications for the

job market and jobs expected to be lost. We rely on the IMPLAN model for this latter analysis.

Scenario Assumptions: Retaliatory Tariffs by China and Mexico

The scenario includes the imposition of retaliatory tariffs by China and Mexico on selected agricultural commodities produced by the U.S. The levels of the tariffs imposed by each country and the commodities affected are presented in table 2.

Table 2. Retaliatory tariff levels by country and commodity

Country	Commodities	Retaliatory Tariff
China	Pork	50%
	Wheat	25%
	Corn	25%
	Soybeans	25%
Mexico	Pork	20%

Shares of U.S. imports in the market

As indicated in the methodology outlined above, to implement the scenario we first project the U.S. market share in the countries of interest. For this purpose, we rely on historical shares of the imports by the countries and commodities of interest from the U.S., which are obtained from USDA Foreign Agricultural Service GAIN Reports. To implement the scenario, the baseline shares for U.S. imports by country and commodity are exogenously reduced based on the magnitude of the retaliatory tariffs as indicated in table 3. These shares are maintained throughout the nine-year projection period.

Table 3. U.S. share in imports of China and Mexico in the baseline and scenario

Country	Commodities	U.S. share in imports	
		Baseline (average of last 3 years)	Scenario
China	Pork	38%	0%
	Wheat	28%	0%
	Corn	84%	60%
	Soybeans	40%	15%
Mexico	Pork	90%	15%

Scenario Results: Impact on U.S. Agricultural Sector and National Economy

We present two types of results in this section: the U.S. and global impacts of the retaliatory tariffs as well as the national economic impacts on the agricultural and industrial sectors. In terms of the U.S. and global impacts, we focus mainly on the affected commodities.[4] When relevant, we present differences between short-run and long-run expected impacts of the retaliatory tariffs.

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[4] A complete set of results for all countries and commodities included in the CARD/FAPRI modeling system is available from the authors upon request.

For the impacts on agriculture, results are expressed in percent change relative to the baseline as the average of either the first three years of the projection (short run) or the last three years of the projection period (long run). The short run is the relevant period to consider if the tariffs are expected to be short lived. However, if the tariffs are expected to be long term, the damages will accumulate over the entire projection period, and both short- and long-term time horizons are relevant. The results are presented as an average of these years to reduce distortions that may be caused by an unusual year.

In terms of the impacts on the national economy, we measure the total, multiplied-through gains or losses to the U.S. economy based on quantity changes in production of wheat, corn, soybean, and pork in the retaliatory tariff scenario relative to the baseline. As previously indicated these impacts are measured using an input-output model of the national economy.[5] The model is based on the initial output of each commodity to the U.S. economy for 2017. The deviations between the baseline and the scenario production for each category are then modeled as proportionate change values relative to those respective anchor amounts had they occurred in 2017. All financial values in the following analyses are expressed in 2017-dollar amounts even though the modeled activity occurs in the future.

For the national economy impacts, results reflect the average annual deviations from the baseline under the scenario for the short run (first 3 years of the projection period) and the long run (last 3 years of the projection period) of the scenario, one for each commodity and one that combines all four into a group total.[6] Specifically, the tables show the amount of economic activity in the U.S. that is gained or lost based on the scenario. The modeling does not factor in offsets, alternative uses of farmland, or other countervailing factors. The results present the plus or minus value of jobs and other critical economic data associated with the scenario-driven changes.

Impact on U.S. Pork and Other Meats

As expected from economic theory, the introduction of tariffs and other barriers to free trade have the impact of reducing imports (and thus exports) at a global level (see table 1). We present the following results in terms of either the average of the first three years of the projection (short run) or the average of the last three years of the projection period (long run).

In the case of pork, two distinct impacts can be observed when looking at the short versus the long run, as reflected in table 4. The price of pork and the consumption variables (especially trade) adjust immediately after the introduction of the retaliatory tariffs. However, inertias of the processes and long cycles in animal production result in lower responses on the production side. Thus, in the short run, producers see lower prices without being able to quickly adjust production, leading to economic losses. As economic losses accumulate, some producers leave the sector (or go bankrupt) while

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[5] IMPLAN, Inc., is the modeling system and the initial national data base source.
[6] The model also produces results for the short run and the long run that itemize the job impacts in the top 40 sectors affected by the average annual changes in economic activity analyzed for the four commodities. These results are available from the authors upon request.

Table 4. Changes (scenario relative to baseline) in U.S. pork over the projection period

Percent change in supply and utilization of U.S. pork

Year of projection	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Supply									
Beginning Stocks	0.0%	1.0%	-0.3%	-2.0%	-2.7%	-2.8%	-2.7%	-2.8%	-2.8%
Imports	-49.2%	-38.2%	-28.4%	-25.0%	-28.8%	-32.2%	-34.0%	-35.6%	-36.7%
Production	-0.4%	-1.4%	-2.6%	-3.2%	-3.2%	-3.2%	-3.3%	-3.3%	-3.3%
Total	-1.6%	-2.5%	-3.4%	-3.9%	-4.0%	-4.1%	-4.2%	-4.2%	-4.3%
Disappearance									
Domestic Use	5.6%	5.7%	5.0%	4.7%	4.7%	4.8%	4.9%	5.0%	5.2%
Exports	-28.6%	-30.5%	-30.3%	-30.2%	-30.3%	-31.2%	-31.7%	-31.9%	-32.0%
Total	-1.7%	-2.5%	-3.5%	-3.9%	-4.1%	-4.1%	-4.2%	-4.3%	-4.3%
Ending Stocks	1.0%	-0.3%	-2.0%	-2.7%	-2.8%	-2.7%	-2.8%	-2.8%	-2.8%
Barrows & Gilts Price									
Natl. Base 51-52% live equiv.	-12.5%	-11.8%	-10.4%	-10.4%	-10.5%	-11.1%	-11.2%	-11.8%	-12.1%

Average annual deviation in relevant national economic variables for U.S. pork production changes

Impact Type	Jobs	Labor Income ($000)	Value Added ($000)	Output ($000)
Short Run (first 3 years of the projection period)				
Direct	-3,393	-161,284	-191,470	-330,361
Indirect	-1,004	-56,312	-91,271	-221,278
Induced	-1,835	-95,136	-166,313	-303,951
Total	-6,232	-$312,732	-$449,054	-$855,590
Long Run (last 3 years of the projection period)				
Direct	-8,318	-395,388	-469,390	-809,881
Indirect	-2,460	-138,050	-223,751	-542,465
Induced	-4,499	-233,226	-407,717	-745,137
Total	-15,277	-766,663	-1,100,857	-2,097,483

others reduce production. This is the reason behind the gradual but increasing fall in production over the projection period.

Overall, global trade is reduced by almost 10% as a result of the tariffs. This is the case throughout the projection period. The retaliatory tariffs on U.S. pork from China and Mexico reduce the global demand for pork. U.S. pork exports decline by 32% relative to the baseline (average of the last 3 years). The lower demand leads to a decline in Barrows and Gilts (51-52% live equivalent) pork prices by about 12% for U.S. producers (see table 4). The table shows that adjustments in prices and trade numbers occur from the beginning of the projection and last until the outer years.

The reduction in global demand for U.S. pork is more pronounced than that of total demand as countries imposing the tariffs are specifically targeting pork of U.S. origin. The pronounced impact on the global demand for U.S. pork reflects a combination of two different effects. First, the tariff results in reduced total trade, i.e. global trade destruction. Second, there will be substitution of trade by China and Mexico away from the U.S. and towards competing countries in the global markets, i.e. trade diversion. As a result, other countries increase their participation in the international markets to take the place of the U.S. Countries like Brazil, Canada, and the European Union increase their net exports because of the tariffs targeting U.S. products.

China and Mexico do not replace all their imports as they shy away from U.S. exports. Instead they reduce the levels procured from the international markets by 29.2% and 6.5% respectively. These changes result from higher prices in the domestic market in China and Mexico, which incentivize domestic production and ration demand.

In the case of the U.S., lower prices encourage domestic use, which increases by 5.0% both in the short and long run since consumers can quickly adjust consumption patterns in response to changes in prices. The lower price of pork also leads to a decline in production by 3.3%, which is only partially offset by lower feed costs (as corn and other feed grain prices decline).

Domestic disappearance of beef declines by 1.4% in the long run despite reductions in the price of beef. This comes from a substitution away from beef to the now relatively cheaper pork. Lower domestic demand for beef allows for enhanced exports of this meat. Similarly, broiler exports increase by 7.3% because of lower domestic use and higher production. Relatively expensive pork in international markets increases demand for U.S. broilers.

Table 4 also describes the short-run and long-run broader economic effects in terms of annual average deviation from the baseline for pork production. Since declines in domestic feed demand due to reduction in pork production have already been factored into the scenario, the input-output model is modified to avoid double counting corn and soybean production losses due to decreased pork demand. In the table, direct activity describes the specific industry's total output, all payments that it makes to value added and to intermediate inputs, as well as the actual number of jobs in that industry. Indirect activity is the supply-chain-based economic activity that is stimulated by the purchase of goods and services as inputs into the direct sector. As the direct

sector's demand for goods and services changes, so does the amount of economic activity in its supply chain. Induced activity occurs when jobholders in the direct and indirect sectors convert their labor incomes into household spending, thus stimulating another set of business activities in the economy. The total economic effect is the sum of the direct, indirect, and induced activities.

Total output represents the value of goods or services that are produced by an industrial sector over the course of a year or, in the case of a shock to the model, changes in final demand in an industry's output. In producing total output, payments are made to labor income, to investors, and to governments in the form of indirect tax payments. These payments constitute value added, and they are analogous to gross domestic product. Labor income is a subset of value added, and it reflects the value of wages and salaries received by workers as well as the value of employer provided (or mandated) benefits. Jobs are the number of full and part-time jobs in the economy; the model does not report out full-time equivalencies.

In the short run, table 4 shows a direct decrease of $330.4 million in output, resulting in 3,393 lost farm level jobs (including farmers) reflecting lost earnings totaling $161.3 million in labor income. This reduction in pork production indirectly suppresses $221.3 million of output at the national level supporting 1,004 jobholders with annual earnings totaling $56.3 million. When considering the direct and indirect sector jobholders converting their labor incomes into household spending, an additional output contraction of $304 million is estimated, with the effect of eliminating 1,835 jobs and a labor income of $95.1 million. Combined, this loss in pork production would cost the economy $855.6 million in total national output and $449 million in value added, of which $312.7 million would be labor income of 6,232 jobholders.

In the long run, a reduction in pork production results in $2.10 billion lower total U.S. industrial output and $1.10 billion in reduced value added, of which $766.66 million is labor income lost due to 15,277 fewer jobholders. While it is tempting to focus on the largest value in the table, the output amount, we properly measure gains or losses to the economy using the value-added, given that value added is analogous to GDP. Accordingly, we conclude that, in the long run, the annual average cost nationally in the scenario relative to the baseline is $1.1 billion in value added (or GDP) for pork production.

Impact on U.S. Crops

Soybeans

Retaliatory tariffs from the main importer of U.S. and world markets for soybeans, namely China, have a strong impact on U.S. export levels, which fall by about 15% relative to the baseline. Table 5 makes clear that both short-run and long-run impacts are similar. China's share of soybean import markets amounts to roughly 60%. The reduced Chinese and global demand for soybeans leads to an almost 12% reduction in the price received by U.S. farmers in the long run. Notice that in this case, prices of soybeans drop relative to the baseline in a significant way (almost 10%) in the short run, mainly because of the immediate reduction in the export demand for U.S.

soybeans following the retaliatory tariffs. The decline in soybean prices increases gradually over the long run.

Lower prices lead to a decline in soybean area harvested and yield, resulting in a reduction in soybean production of 2%. It should be noted, however, that the production declines are mitigated by reductions in returns of crops competing with soybeans for area (for example, corn and wheat, which also see lower prices due to retaliatory tariffs). Given that soybeans are an annual crop, producers can reduce area harvested in the short run. Table 5 shows that farmers do just that. The behavior of the prices and harvested area of soybeans, both declining in the short run and then remaining at similar levels, indicate that the impacts in terms of lower revenues (as a result of the changes in both prices and production quantities) are felt even in the short run.

As reflected in table 5, relatively cheaper soybeans encourage crushing and thus, production of soybean meal and soybean oil. The U.S. shifts away from exporting soybeans to a scenario in which more soybeans are processed domestically and the production and exports of soybean meal and soybean oil strongly expand. The expansion in exports on soybean meal (as a result of more production) is enhanced by the lower domestic use for soybean meal due to the reduced size of the pork sector after the tariffs are imposed. The capacity to shift to exports of co-products rather than soybean seeds embedded in the model might be behind the larger reduction in exports of the oilseeds obtained in this study as compared to other studies (see table 1).

Additional supplies and lower domestic demand have the impact of lowering prices of soybean meal by about 2%, relative to the baseline. Lower prices of soybean meal tend to reduce returns to crushing and the supply for soybean oil. However, as the demand for soybean oil remains strong, the price of this co-product tends to increase with the tariffs. Additionally, reduction in the price of soybeans favors production of other oilseeds like canola and sunflower as these crops become relatively more profitable and better able to compete for land.

Scenario-driven soybean production impacts on the economy are presented in table 5. In the short run, production declines result in a $2.36 billion fall in total output nationally and $1.16 billion decrease in total value added, of which $741.93 million is a loss of labor income from 10,098 lost jobs annually, over the period measured. Table 5 also shows the long-run soybean average annual impacts. After all direct effects multiply through, production declines would result in $2.21 billion lower total output nationally and $1.09 billion in reduced total value added, of which $692.92 million would be lost labor income to 9,431 fewer jobs annually.

Table 5. Changes (scenario relative to baseline) in U.S. soybeans over the projection period

Percent change in supply and utilization of U.S. soybeans

Year of projection	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Harvested Area	-2.2%	-2.9%	-2.7%	-3.1%	-2.6%	-2.5%	-2.0%	-1.8%	-1.6%
Yield	0.0%	0.0%	-0.1%	-0.2%	-0.3%	-0.3%	-0.4%	-0.4%	-0.5%
Supply									
Beginning Stocks	0.0%	11.2%	10.2%	12.0%	10.4%	11.5%	11.2%	12.4%	13.0%
Production	-2.2%	-3.0%	-2.8%	-3.3%	-2.9%	-2.8%	-2.4%	-2.2%	-2.1%
Imports	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Domestic Use	7.0%	7.8%	8.0%	7.5%	7.4%	7.3%	7.5%	7.5%	7.5%
Crush	7.3%	8.2%	8.4%	7.9%	7.8%	7.7%	7.8%	7.7%	7.7%
Seed, Residual	3.4%	3.0%	2.8%	2.4%	3.0%	3.5%	4.1%	4.3%	4.8%
Exports	-15.9%	-16.4%	-16.7%	-16.9%	-16.3%	-15.9%	-15.5%	-15.2%	-15.0%
Total Use	-2.9%	-2.9%	-2.9%	-3.2%	-2.9%	-2.8%	-2.4%	-2.3%	-2.1%
Ending Stocks	11.2%	10.2%	12.0%	10.4%	11.5%	11.2%	12.4%	13.0%	12.9%
Farm Price	-9.8%	-9.6%	-9.7%	-9.3%	-10.0%	-10.4%	-11.3%	-11.8%	-12.3%

Average annual deviation in relevant national economic variables for U.S. soybean production changes

Impact Type	Jobs	Labor Income ($000)	Value Added ($000)	Output ($000)
Short Run (first 3 years of the projection period)				
Direct	-1,544	-278,429	-354,220	-842,336
Indirect	-3,983	-227,951	-398,216	-766,916
Induced	-4,572	-235,549	-411,768	-752,949
Total	-10,098	-$741,929	-$1,164,205	- $2,362,201
Long Run (last 3 years of the projection period)				
Direct	-1,442	-260,036	-330,820	-786,691
Indirect	-3,720	-212,892	-371,910	-716,253
Induced	-4,270	-219,989	-384,567	-703,209
Total	-9,431	-692,916	-1,087,297	-2,206,153

Corn

As in the case of soybeans, China's retaliatory tariffs have a strong impact on the exports of corn resulting in a 37% reduction relative to the baseline. With lower demand for U.S. corn exports and a weakened domestic demand as a result of the shock on pork production, the price received by U.S. farmers declines by almost 9% (see table 6). However, in contrast to soybeans, the model projects that the impacts on the corn sector are much lower in the short run than in the long run. This might reflect the fact that the magnitude of the shock on U.S. soybean exports because of the lower demand from China is greater than the magnitude of the shock on corn. Additionally, China is by far the largest importer of soybeans, but not of corn.

Lower prices also weaken corn's position as a competitor for land, and harvested area falls by about 5% relative to the baseline. With lower area utilization, production decreases by nearly 5% as yields also fall. The lower area also reduces the demand for seed. The shrinking demand in the livestock sector because of the tariffs on pork explains the small increase in feed use despite the large reduction in the price of corn. In addition, despite the relatively large price decline, there is only a small (0.9%) increase in food and residual use.

In terms of short-run national economic impacts, table 6 shows a decrease of $793.06 million in output, resulting in 2,644 lost farm level jobs and $80.85 million in lost labor income. After considering all direct, indirect, and induced effects, corn production losses would cost the economy $2,294.18 million in national output and $966.36 million in value added. Labor income decreases by $516.44 million and the number of jobs falls by 10,770. In the long run, the decline in corn production produces a $7.55 billion reduction in total output nationally, $3.18 billion in lower value added, including $1.7 billion in lost labor income and 35,466 less jobs annually.

Wheat

Given the smaller share of China in the import market for wheat relative to corn and the relatively low U.S. share in China's wheat market relative to corn, trade impacts are muted for wheat, declining only by 1.5% (table 7). While important in terms of economic activity and farm income, these effects are relatively low when compared to the changes in corn, soybeans, and soybean products.

Wheat area harvested remains fairly stable relative to the baseline, increasing by 0.2% despite a price drop of 8%. The relative stability (or slight increase) is due to the comparatively larger decline in the prices of the crops that compete for land (most notably, about 10% for corn and 12% for soybeans). Production remains unchanged as lower yields offset the area expansion. Lower prices incentivize feed use, despite a shrinking livestock sector.

The results show a similar pattern for wheat prices as for corn prices. Again, the importance of China in the wheat export market is much more subdued than that for

Table 6. Changes (scenario relative to baseline) in U.S. corn over the projection period

Percent change in supply and utilization of U.S. corn									
Year of projection	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**
Harvested Area	-0.2%	-2.3%	-2.5%	-1.6%	-2.4%	-3.0%	-4.0%	-4.7%	-5.2%
Yield	0.1%	0.1%	0.1%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	-0.2%
Supply									
Beginning Stocks	0.0%	5.9%	7.6%	3.3%	6.7%	7.2%	9.5%	10.7%	11.2%
Production	-0.1%	-2.2%	-2.4%	-1.6%	-2.4%	-3.0%	-4.1%	-4.9%	-5.4%
Imports	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Domestic Use									
Feed, Residual	1.7%	1.7%	0.3%	1.0%	0.7%	0.7%	0.6%	0.2%	0.2%
Fuel Alcohol	0.1%	0.2%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%
HFCS	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%
Seed	-2.1%	-2.2%	-1.4%	-2.1%	-2.7%	-3.7%	-4.3%	-4.8%	-5.8%
Food, Other	0.4%	0.8%	0.5%	0.6%	0.6%	0.7%	0.9%	0.9%	1.0%
Exports	-14.1%	-24.4%	-21.1%	-21.3%	-25.4%	-29.2%	-34.9%	-37.1%	-40.3%
Total Use	-0.7%	-2.2%	-2.1%	-1.9%	-2.5%	-3.2%	-4.3%	-4.9%	-5.6%
Ending Stocks	5.9%	7.6%	3.3%	6.7%	7.2%	9.5%	10.7%	11.2%	13.8%
Farm Price	-3.6%	-6.8%	-4.3%	-5.3%	-5.8%	-6.8%	-8.3%	-8.6%	-9.7%

Average annual deviation in relevant national economic variables for U.S. corn production changes				
Impact Type	**Jobs**	**Labor Income ($000)**	**Value Added ($000)**	**Output ($000)**
Short Run (first 3 years of the projection period)				
Direct	-2,644	-80,855	-180,548	-793,070
Indirect	-4,937	-269,937	-496,350	-971,700
Induced	-3,189	-165,646	-289,459	-529,419
Total	-10,770	-$516,438	-$966,358	-$2,294,189
Long Run (last 3 years of the projection period)				
Direct	-8,708	-266,258	-594,547	-2,611,586
Indirect	-16,256	-888,905	-1,634,485	-3,199,817
Induced	-10,502	-545,473	-953,192	-1,743,381
Total	-35,466	-1,700,635	-3,182,224	-7,554,784

Table 7. Changes (scenario relative to baseline) in U.S. wheat over the projection period

Percent change in supply and utilization of U.S. wheat									
Year of projection	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Area Harvested	1.1%	1.6%	0.6%	0.3%	0.4%	0.4%	0.4%	0.2%	0.1%
Yield	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%
Supply									
Beginning Stocks	0.0%	0.7%	2.5%	2.3%	2.2%	2.5%	2.8%	3.4%	3.8%
Production	1.1%	1.6%	0.6%	0.3%	0.4%	0.4%	0.3%	0.2%	0.0%
Imports	0.5%	-1.6%	-2.1%	-1.9%	-2.1%	-2.3%	-2.7%	-3.0%	-3.3%
Domestic Use									
Feed, Residual	-6.8%	-2.3%	0.4%	1.3%	1.1%	1.0%	1.5%	2.5%	3.4%
Seed	0.4%	-0.4%	-0.7%	-0.6%	-0.6%	-0.6%	-0.7%	-0.8%	-0.8%
Food, Other	0.1%	0.4%	0.4%	0.4%	0.4%	0.5%	0.6%	0.6%	0.7%
Exports	3.2%	1.6%	0.9%	-0.1%	-0.2%	-0.4%	-0.9%	-1.4%	-2.1%
Total Use	0.8%	0.7%	0.6%	0.2%	0.2%	0.1%	0.0%	-0.2%	-0.4%
Ending Stocks	0.7%	2.5%	2.3%	2.2%	2.5%	2.8%	3.4%	3.8%	4.2%
Farm Price	-0.9%	-5.1%	-4.6%	-4.9%	-5.4%	-6.1%	-7.3%	-8.1%	-9.0%

Average annual deviation in relevant national economic variables for U.S. wheat production changes				
Impact Type	Jobs	Labor Income ($000)	Value Added ($000)	Output ($000)
Short Run (first 3 years of the projection period)				
Direct	350	10,413	22,502	98,813
Indirect	654	34,764	61,861	120,809
Induced	422	21,333	36,076	66,015
Total	1,426	66,510	120,439	285,637
Long Run (last 3 years of the projection period)				
Direct	52	1,548	3,344	14,686
Indirect	97	5,167	9,194	17,956
Induced	63	3,171	5,362	9,812
Total	212	9,885	17,900	42,454

soybeans. While in the short run there is a price reduction of close to 4% relative to the baseline, the decline in wheat price increases to between 8 and 9% in the long run.

Table 7 also shows the short-run and long-run wheat average annual national economic impacts. In the short run, production increases result in an additional $285.64 million in total output nationally and $120.44 million value added. Labor income increases by $66.50 million from 1,426 additional jobs annually. There are also long-run gains in wheat production. Total output would grow by $42.45 million and value added would increase by $17.90 million, of which $9.89 million would be labor income to 212 jobholders.

National Economic Impacts: Wheat, Corn, Soybeans and Pork Combined

The summed consequences of the scenario are contained in table 8. The short-run average annual scenario change over the baseline would result in $5.23 billion in reduced national total output and $2.46 billion in lower value added, including $1.50 billion in lost labor income attributable to 25,674 fewer jobs annually, on average, over the period assessed. In the long run, national output declines by $11.82 billion while value added falls by $5.35 billion, of which $3.15 billion is lost labor income arising from 59,963 fewer jobs annually.

Table 8. Average annual deviation (scenario relative to baseline) for U.S. soybeans, corn, wheat and pork combined production over the projection period

Impact Type	Jobs	Labor Income ($000)	Value Added ($000)	Output ($000)
Short Run (first 3 years of the projection period)				
Direct	-7,231	-510,155	-703,737	-1,866,954
Indirect	-9,269	-519,436	-923,976	-1,839,086
Induced	-9,174	-474,998	-831,465	-1,520,303
Total	-25,674	-$1,504,589	-$2,459,177	-$5,226,343
Long Run (last 3 years of the projection period)				
Direct	-18,416	-920,134	-1,391,413	-4,193,471
Indirect	-22,339	-1,234,680	-2,220,952	-4,440,580
Induced	-19,207	-995,517	-1,740,113	-3,181,915
Total	-59,963	-3,150,330	-5,352,477	-$11,815,966

4. Final Remarks

This study examines the impact of retaliatory tariffs imposed by China on pork, corn, wheat, and soybeans, and by Mexico on pork using an augmented CARD/FAPRI agricultural modeling system in conjunction with the IMPLAN model. It shows that retaliatory tariffs result in trade diversion as imports to China and Mexico are diverted from the U.S. to other suppliers, reducing the U.S. market share in each country's imports. The introduction of tariffs also results in trade destruction, as the aggregate level of trade is also reduced. Domestic prices of the impacted agricultural commodities increase in China and Mexico, inducing reductions in consumption and growth in production in these countries leading to trade destruction.

The trade diversion and trade destruction impacts reduce demand in the U.S. leading to lower prices in the U.S. domestic market. The lower demand of U.S. exports results in lower production, increases in domestic consumption and stocks. Yearly farm-level revenue (for the average of the last 3 years of projection) decline by 15%, 14%, 13%, and 8% for pork, soybeans, corn, and wheat producers, respectively.

The initial increase in the domestic price in China and Mexico due to the tariffs is somewhat moderated as U.S. prices decrease with the reduced export demand from China and Mexico. On the other hand, the initial increase in the world price faced by other countries is moderated as U.S. exports to other countries are encouraged with its falling domestic price and increasing world price due to trade diversion. In terms of regional consequences, output declines in some U.S. farm and manufacturing sectors. This decline has negative multiplier effects throughout the supply chain of the trade-affected sectors and will result in job, labor income, and value-added reductions nationally. Over the projection period, the impacts of the retaliatory tariffs on prices, trade and the national economy tend to be more muted in the short term relative to the long term.

While the directional changes in the economic variables mentioned here could have been anticipated based on conceptual economic models, the magnitudes of the effects is an empirical question and its quantifications need the use of models of the sort used in this study. The full magnitude or consequences of the trade distortions on the affected commodities is still to be seen and have not fully unfolded. However, the results presented in this study indicate that negative economic impacts could be significant and that a quick and satisfactory resolution is urgent.

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