Effects of Chinese Import Tariffs on US Pork Exports: A Computable General Equilibrium Model Analysis

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Abstract

Two powerful nations; the United States of America and China have recently embarked on a tit-for-tat trade war by imposing tariffs on imports and exports of goods necessary to facilitate international trade to and from both nations. As of September 2019, the tariff imposed by U.S. was 25% on Chinese goods mainly from steel and aluminum with China retaliating with up to 25% on U.S. agricultural commodities including pork and pork products.

With China being one of the major importers of U.S. pork and pork products, the paper seeks to investigate the economy-wide effects of Chinese import tariffs on U.S. pork exports Computable General Equilibrium under static specific factors model is applied to 2018 U.S. Census data on managers, professionals, service, and production) across manufacturing, the rest of agriculture, pork industries. The model assumes competitive production with constant returns, perfect labor mobility across industries and full employment. Substitution matrix consisting of industry shares and factor shares are constructed. Factor shares are payments going to productive factors and industry shares are portions of factors employed by industry. Simulations with different tariff rates are performed with various vectors of price changes leading to the decrease in pork output and prices.

Keywords: **Trade war, Tariff, Pork, Computable Equilibrium Analysis, Factor shares, Industry shares**

BACKGROUND

Since 1995, the United States has been a net exporter of pork and pork products on the international market. Bilateral trade between China and the U.S has been well-established, especially for pork and pork products, as a significant commodity traded by these two giant economies. China, including Hong Kong, has steadily become a vast nation as it has accounted for about 11% of U.S. pork exports becoming the third-largest importer after Mexico being the largest and Japan the second largest of U.S. pork and pork products in 2016(USDA Report, ERS 2019)

The trade war between the United States and China commenced in 2018 through the implementation of the Trade Expansion Act Section 232. Tariffs on selected Chinese products, including imported into the United States. China retaliated by imposing an average of 25% tariff on selected products from the United States, including agricultural commodities such as soybean, wheat, sorghum, and other agricultural products. The pork and pork variety industry was affected by an average of 16% import tariff on pork and pork products from the United States (Regmi,2019 Congressional Research Report R45929).

However, multiple trade negotiation talks between both countries have occurred amid China's outbreak of African swine fever. China is set to still implement more retaliatory tariffs on U.S. products effective December 15, 2019 (USDA, 2019). Retaliatory tariffs imposed by China have affected all U.S. agricultural products exported to China as of September 2019.

Many economists have made literary analysis and predictions on the implications of the trade war on the various aspects of the economies of these two giant nations and other global economies.

This paper seeks to narrow the effect of the U.S.-China trade war engaged in Pork production and how this trade policy is affecting the business operations in this sector.

The paper further seeks to evaluate the effect of the Chinese import tariff on the U.S. pork and pork variety industry by examining the implications of the tariff on the price of pork & pork products from the U.S. on the international market.

Literature review

The literature on the tariff imposition is gradually increasing, spanning from analytical perspectives on the U.S. policy even before the imposition while others have assessed from empirical viewpoints such as Li (2018) who sought to assess the effect the bilateral trade retaliation using numerical general equilibrium methodology. Ameti, Redding, &Weinstein (2019) sought to find the implication of the incidence of the tariffs on consumers and to ascertain whether the government intervention programs for American farmers through tariff revenues are enough to compensate for the losses borne by U.S. farmers and consumers. Ameti et al. (2019) concluded that tariff revenue to be generated from the imposition of the tariffs might not be enough to offset the loss of about $6.9bn as of November 2018. (Li, Zhang, & Hart, 2018) gave insight that, U.S. share in China's import demand for pork is 11.9% while China's share in total global import is 14.5%. China deals in the intra industry trade for Pork.

Over the years, various nations have resorted to trade protectionism as a tool to shield their domestic industries. Hence either tariffs or quotas are implemented. Tariffs are taxes imposed on goods imported from a nation, whereas quotas are physical quantity restrictions on goods imported from other nations too (Thompson, 2001). China, in recent years, has become a giant in international trade with the U.S. as it climbed up steadily to become the third-largest exporting market for U.S. products. Tariffs on pork were implemented on April 2, 2018 by the Chinese government

COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

Computable general equilibrium (CGE) models simulate the interactions among producers and consumers within an economy or group of economies in markets for goods, services, labor, and physical capital. The distinguishing feature of a CGE model is its economy-wide coverage and multi-sectoral nature (Reinert &Roland-Holst,1991) as compared to the partial equilibrium model, which employs traditional demand and supply functions as the only focus whiles assuming all other areas of the economy stays the same. CGE models simulate the interactions among producers and consumers within an economy. This is achieved by analyzing the impact of a policy across all the various markets in an economy. This includes the factor, product, and intermediate markets. It considers all sectors of the economy.

3.1 Assumptions

The specific factor model the basis for the CGE model as a fundamental model of production and trade (Boadu-Ofori, Yeboah & Thompson,2012).It assumes full employment of all factors of production; capital, labor, and energy, constant returns; meaning that a percentage change in all factors employed results in the same percentage change in output, perfectly competitive pricing in which firms maximize profits drive to the zero level in equilibrium, cost minimization function to illustrate that nation reduce cost by substituting an expensive factor for a cheaper factor (Jones,1965). There is perfect mobility of all factors except for capital in the short run. However, each industry utilizes its capital specific to that industry. The model simulates the effect of the Chinese tariff imposition on factor prices and outputs in the United States. Further, the static specific factor model determines the impact of the tariffs on the Pork Industry. The model assumes competitive production constant returns, perfect labor mobility across industries, and full employment. This paper categorizes the industries in the economy as follows; manufacturing (M), service(S), rest of agriculture, and Pork. The underlying mathematical model is a substitution matrix of the factor and industry shares. Substitution matrix consisting of industry shares and factor shares are constructed.

Application of The Model

Employment of every factor (capital, labor, and energy) is represented by $v=Ax$ where v is the inputs vector, A represents the matrix of cost-minimizing unit inputs, and the output vector is x. We consider the supply of factors to be exogenous and perfectly inelastic fortifying v=Ax. Differentiating the full employment function results in $dv=xdA+Adx$. The substitution terms $S_{ik} = \sum_j x_j(\delta a_{ij}/\delta w_k)$ summarizes changes in unit inputs dA utilized by cost-minimizing firms when faced with changes in prices wk. Every single input utilized is homogeneous of degree zero in factor prices and given homogeneity; they are independent of output. Further, we let the matrix substitution terms be represented by S; hence, $dv=Sdw + Adx$. This is converted into elasticity form to make $v'=\sigma w'+\lambda x'$ (will mark this equation as (1)), where ′ represents percentage change, the matrix of cross-price input substitution elasticities $\sigma_{ik}=\sum_j\lambda_{ij}a_{ij}'/w_k'$ is represented by σ, and λ denotes the matrix of industry shares $\lambda_{ij}=a_{ij}xj/v_i$. By this, the summation of rows of λ is 1 when there is full employment.

Considering competitive pricing, $p=A^Tw$ is implied. The vector of output prices is p and w denotes the factor price vector. We assume that the U.S. economy is a price taker in the pork market. $wdA^T=0$ is an enveloped condition implied by cost minimization, which leads to $dp = A^Tdw$. Then again, converting this to elasticity form would be $p'=\theta^Tw$ (let us mark this equation as (2)). θ being the matrix of factor shares $\theta_{ij}=\sum_i a_{ij}w_i/p_j$. Competitive pricing means the summation of the rows of θ^T is 1.

Bring (1) and (2) together would be,

$$\begin{bmatrix} \sigma & \lambda \\ \theta^T & 0 \end{bmatrix} \begin{bmatrix} w' \\ x' \end{bmatrix} = \begin{bmatrix} v' \\ p' \end{bmatrix} = \begin{bmatrix} 0 \\ p' \end{bmatrix}$$

Where: σ is a 9x9 matrix and is made up of aggregate price elasticities factor demand.

λ is a 9 x 4 matrix which details industry shares, and

θ^T represents a transposed matrix of factor shares, which is dimensioned 4x9.

The vector w denotes endogenous factor prices, while x represents exogenous outputs. Exogenous factor endowment is represented by *v* and *p* is the exogenous world prices of goods facing the economy.

Factor Shares and Industry Shares

We first compute factor and industry shares as the initial step in building an applied specific factor model (Boadu et al., 2012; Thompson,1996).

Table 1 presents the factor payments in the various industries (Pork, Manufacturing, Service, and Rest of Agriculture) for 2018. Data on labor employment and payments in the manufacturing, service, and agriculture industries were sourced from The U.S. Bureau of Labor Statistics (BLS, www.bls.gov, 2018), U.S. Census Bureau and U.S. Department of Agriculture (USDA, www.usda.gov, 2018. Classification of sector data was gathered using the North American Industry Classification System (NAICS). Data on values added were taken from the Bureau of Economic Analysis (BEA, www.bea.gov, 2018), and Federal Reserve Economic Data (FRED, https://fred.stlouisfed.org, 2018) Data used was gross state products for each industry. According to the Bureau of Economic Analysis, the Pork sector is represented by Animal production; except cattle and poultry and eggs, Energy data was obtained from the Energy Information Administration (EIA, www.eia.gov, 2018). Energy data attributable to pork sector was estimated to be 40% of total energy consumption for agriculture. Energy expenditures for transportation represent that of services. Capital is residue of the value-added in each industry. The paper uses static data taken at a single point in time as nominal values for factor payments and value-added.

Table 2 shows the payments to the various factors of production. Labor is categorized into four types, namely, management workers (m), service workers(s), professional workers (pw), and production workers (p). Productions workers include farmers in the pork industry. Value added is the contribution of labor and capital to the value of a product on top of the value of intermediate inputs (Reinert and Roland-Holst, 1991). Industry value added in each column is the total addition of all factor payments in that column that yields the total. For example, the value-added for the Pork and pork variety industry is \$33.50 billion, and that of the rest of the Agricultural industry is \$133 billion.

Table 2 details the factor share θ matrix derived from the factor payments. Factor shares are the portion of the total payments that each productive factor receives. In sector *j,* the dollar value of factor input i is $w_{ij} \equiv w_i v_{ij}$ with w_i being the factor price of i and v_{ij} representing the quantity of i used in j. The factor share of i is hence, $\theta_{ij} = w_{ij}/y_j$ with y_j representing the value-added in sector j. The value-added in the Pork and pork variety industry (B) is \$33.5billion, and the factor share for service workers (s) is 1.2% (0.4/33.50=0.012) the table 2 indicates that the major portion of factor shares across all sectors is received by capital receives the major portion of the factor shares across sectors especially in the pork industry. This shows the influx of mechanization in agriculture production in recent times.

Service workers (s) in the service industry (S) have the biggest share of 27% than all other labor in other industries

Factor income is derived by adding up the values in rows in Table 1. Factors mobility across industries that shows the same prices lead to industry shares in Table 3. Industry share is denoted mathematically by $\lambda ij = wij/rj$, where rj is the summation of payments received by factor j across sectors. Table 3 illustrates the industry shares matrix λ. It shows the industry shares for each sector of the economy. We can conclude that professional workers in the service sector for instance, have the largest industry share of almost 85%, ($1015.79billion/$1189.72 billion). It can also be seen that the pork and pork variety industry has workers attaining the least share of the factor income whereas production workers in the manufacturing industry receive the largest share which is 83% ($516.36 billion/$616.88 billion).

Elasticities

Substitution elasticities portray the cost-minimizing potential for modifying inputs to factor prices (Thompson & Toledo,2000). In sector j, $E_{ij}k=a_{ij}'/w_{k'}=\theta_{kj}S_{ij}k$ represents the cross-price elasticity between the input of factor i and the payment to factor k. In this, $S_{ij}k$ stands for the Allen (1938) partial elasticity substitution. Cobb-Douglas production shows that $S_{ij}k=1$. Considering constant elasticity of substitution (CES), any positive value can be scaled for the Allen partial elasticity. $\Sigma kEijk = 0$ and own-price elasticities E_{iji}, considering linear homogeneity of cost function are the negative summations of cross-price elasticities.

Each sector's weighted average of cross-price elasticity denotes the substitution elasticities, $\sigma_{ik}=a_{ij}'/w_k'=\Sigma j\lambda ij\ Eijk = \Sigma j\lambda ij\ \theta kjSijk$. The Cobb-Douglas substitution elasticities, as displayed in Table 4, are derived from the factor and industry shares. A change in capital prices rj in one industry has no effect on another. Constant elasticity of substitution would scale the elasticities in Table 4. Taking CES = 0.5 for instance, elasticities would be half of the original in the table.

Table 5 presents the factor price elasticities. It talks about the own price elasticities of the factors of production. Mitchell, Makienko, & Mitchell (2013) explains own price as the percentage in the quantity demanded of a factor because of the percentage change in the price. The production factor with the highest own price elasticity is energy with an elasticity of -0.840. This means that a 10% increase in the price of energy will lead to an 8.4% decrease in the use of energy. Pork and pork variety has the elasticity of -0.029 implying that a 10% increase in the price of pork will cause a decrease in the unit of pork and pork variety by 0.29%.

Comparative Static Elasticities

Using Cramer's rule by reversing the system matrix in the table (3), the comparative static elasticities of factor prices are discovered with regards to changes in output prices.

The model contributes by generating comparative static changes in outputs and factor prices as output prices change. Table 5 shows the derived elasticities of factor prices for output price changes. Price elasticities of output with respect to output prices are observed along the production frontier. As the price in a sector increases, output increases because labor attracted to the same and hence, lowering output in other sectors.

Table 5 presents the own price elasticity of pork and pork variety is 1.030 implies that a 10% increase in the price of pork and pork variety would cause a 10.3% increase in the return to pork and pork variety Industry capital investment.

It is observed that wages for the service sector are mostly influenced by the output price increases. In contrast, the impact on wages in the Pork sector due to increased output prices are almost not in existence. The elasticities for services workers (s) in the Service sector (S) (0.9765) implies that a 10% increase in service outputs prices will raise wages for service worker in Service by 9.77%.

The own price elasticity of service (1.164) implies that 10% increase in the price of Service outputs would boost output as labor are attracted from other sectors which would raise productivity and return to capital by 11.2%.

Table 6 presents the elasticities of outputs with respect to changes in output prices. For instance, the own output of the Pork and pork variety Industry of 0.03 implies a 0.3% increase in output as price increases by 10%. Own price elasticity of Agriculture (0.123) implies that 10% increase in service output price will raise the output in the Service sector by only 1.23%.

We rely on economic literature by Inuoye (2018), USDA (2018), for the tariff rates. As of April 2018, the current tariff rate on the pork as classified under the four-digit HS code level was 12-20% tariff with the tendency to increase in the future to about 37-45%.

We conduct simulations using 15% Chinese import tariff as the base, then 25%, 35%, and 45% tariff rates on pork and pork products to determine the changes in output and other input factors. We make predictions under four simulation scenarios. With scenario 1, we assess the effect of the various tariff rates on the various aspects of the U.S. economy. We predict that there would be price decrease of 0.4% for the Pork and Pork variety sector, 3.2% the rest of agriculture and a 0.6% increase for the manufacturing sector. We predict a 0.6% price decrease for the pork and pork variety sector, 5.4% decrease for the rest of agriculture and 1.0% increase in the manufacturing Industry under scenario 2. For scenario 3, using the Chinese tariff of 35%, we predict a 0.84% decrease in the price of pork and pork variety sector, 7.6% price decrease in the rest of agricultural and a 1.4% price increase in manufacturing sector. Finally, under scenario 4, we predict a 1.08% price decrease in pork and pork variety sector, 9.7% price decrease in the rest of agriculture and 1.8% price increase in the manufacturing sector. Table 7 shows them all.

Table 7 is a CGE simulation that demonstrates the impacts of price changes on the U.S. economy, as a result of the Chinese import tariffs, especially the Pork and pork variety industry. For scenario 1, there would be a reduction of 0.019% ,0.45% in the outputs of the pork and pork variety sector and the agricultural sectors respectively due to 0.4% and 3.2% decrease in output prices in both sectors. A 0.6% increase in prices will cause the manufacturing sectors' output to increase by 0.11%. The service industry decreased in output by 0.095% even though there was no direct change in the price of service. Scenario 2 which indicates higher prices depicting that 1% increase of output price would result in a 0.19% change in outputs for the Manufacturing sector.

A reduction of 0.16% is estimated during this ongoing trade war in the output prices of services. The Pork and Pork variety sector and the rest of agriculture will experience 0.03% and 0.75% in outputs as price decreases by 0.6% and 0.54 respectively. For scenario 3, the manufacturing sector sees a 0.27% increase in the output as a result of 1.4% increase in the output price, however, the rest of agriculture experiences a 1.05% decrease in the output. The pork and pork variety sector suffer a decrease in output of 0.04% as a result of 0.84% decrease in the domestic price of the product. Finally, scenario 4 highlights a 0.34% increase in output in the manufacturing sector as price increases by 1.8%. However, all the other sectors suffer decreases in the output. Service sector has its output reduced by 0.29%. Output of the rest of agriculture and pork reduces by 1.35% and 0.06% respectively.

The long-term impact of the trade war on the output is shown in table 8. The model shows an adverse decrease in the output of agriculture less pork and pork variety the most. However, in the long-term, we see a greater change in output considering the same price adjustments.

We assume that outputs follow the same rate at which capital changes given constant returns to capital. Hence, the manufacturing sector is the only sector that experiences a positive output change of 0.71%, 1.19%, 1.67% and 2.14% in all the four scenarios. The rest of agriculture sees 3.69%,6.17%, 8.61% and 11.07% decline in all scenarios respectively. The pork and pork variety sector experiences output decrease of 0.3%, 0.64%, 0.94% and 1.16% in all four scenarios.

Conclusion

We assessed the implications of the Chinese import tariffs on the various aspects of the U.S. economy by applying the specific factor model. The paper applied specific factors model to assess the impact of tariffs imposed by the Chinese government on the sectors in the U.S. economy. The agricultural sector including the pork and pork industry will suffer the most under the trade war.

The U.S. manufacturing sector is the only sector that experiences an increase in output in both the short and long term. Agriculture in general experiences a decrease in output with increasing tariff rates in both the short and long term. Pork and Pork variety specifically experience significant decrease in output in the long term in all scenarios.

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Appendix

Tables

Table 1 Factor payments ($ billions)

	Manufacturing (M)	Service (S)	Rest of Agriculture (A)	Pork (Q	Total
Management Workers (m)	151.91	712.77	0.76	0.16	865.60
Professional Workers (pw)	173.69	1,015.79	0.13	0.11	1,189.72
Service Workers (s)	260.32	3,918.73	3.17	0.40	4,182.62
Production Workers (p)	516.36	90.71	9.28	0.53	616.88
Energy (e)	11.15	17.77	0.74	0.50	30.16
Capital (k)	2,393.47	8,606.33	118.92	31.81	1,1150.53
Total	3,506.90	14,362.10	133.00	33.50	1,8035.50

Table 2 Factor shares matrix θ

	Manufacturing (M)	Service (S)	Rest of Agriculture (A)	Pork (Q)
Management Workers (m)	0.0433	0.0496	0.0057	0.0046
Professional Workers (pw)	0.0495	0.0707	0.0010	0.0032
Service Workers (s)	0.0742	0.2729	0.0238	0.0120
Production Workers (p)	0.1472	0.0063	0.0698	0.0157
Energy (e)	0.0032	0.0012	0.0056	0.0149
Capital (k)	0.6825	0.5992	0.8941	0.9495
Total	1.0000	1.0000	1.0000	1.0000

Table 3 Industry Shares λ

	Manufacturing (M)	Service (S)	Rest of Agriculture (A)	Pork (Q)	Total
Management Workers (m)	0.1755	0.8234	0.0009	0.0002	**1.0000**
Professional Workers (pw)	0.1460	0.8538	0.0001	0.0001	**1.0000**
Service Workers (s)	0.0622	0.9369	0.0008	0.0001	**1.0000**
Production Workers (p)	0.8371	0.1470	0.0150	0.0009	**1.0000**
Energy (e)	0.3697	0.5891	0.0246	0.0166	**1.0000**
Capital (k)	0.2147	s0.7718	0.0107	0.0029	**1.0000**

Table 4 Cobb-Douglas Substitution Elasticities

	Factors					Mfg	Serv	Ag	Pork
	Wm	***w pw***	***ws***	***wp***	***we***	***wM***	***wS***	***wA***	***wQ***
a'm	-0.5940	0.0669	0.2377	0.2377	0.0016	0.0082	0.0419	0.0000	0.0000
a'pw	0.0487	-0.6070	0.2438	0.2438	0.0015	0.0077	0.0614	0.0000	0.0000
As	0.0492	0.0693	-0.6418	0.2603	0.0014	0.0048	0.2568	0.0000	0.0000
Ap	0.0436	0.0519	0.1026	-0.3293	0.0029	0.1259	0.0011	0.0011	0.0000
Ae	0.0455	0.0601	0.1890	0.1890	-0.8404	0.1174	0.2361	0.0026	0.0008
aM	0.0433	0.0495	0.0742	0.1472	0.0032	-0.3175	0.0000	0.0000	0.0000
aS	0.0496	0.0707	0.2729	0.0063	0.0012	0.0000	-0.4008	0.0000	0.0000
aA	0.0057	0.0010	0.0238	0.0698	0.0093	0.0000	0.0000	-0.1096	0.0000
aQ	0.0019	0.0013	0.0048	0.0063	0.0148	0.0000	0.0000	0.0000	-0.0290

Table 5: Elasticity of Factor Prices with respect to Output Prices

	*p'*M	*p'*S	*p'*A	*p'*Q
w'm	0.344	0.655	0.001	0.000
w'pw	0.318	0.681	0.001	0.000
w's	0.189	0.810	0.001	0.000
w'p	0.997	-0.003	0.005	0.000
E'e	0.390	0.601	0.007	0.002
r'M	1.183	-0.181	-0.001	0.000
r'S	-0.163	1.164	-0.001	0.000
r'A	-0.088	-0.030	1.123	0.000
r'Q	-0.027	-0.025	0.000	1.030

Table 6: Elasticity of Output with respect to Output Prices

	*p'*M	*p'*S	*p'*A	*p'Q*
*x'*M	0.183	-0.181	-0.001	0.000
*x'*S	-0.163	0.164	-0.001	0.000
*x'*A	-0.090	-0.032	0.123	0.000
x'Q	-0.015	-0.016	0.000	0.030

Table 7 Pork and Pork Variety Industry Adjustments and Price Changes

	% Price Change				*Factor Price*					*Output*				
Scenarios	**1**	**2**	**3**	**4**		**1**	**2**	**3**	**4**		**1**	**2**	**3**	**4**
					w′m	**0.20**	**0.34**	**0.47**	**0.61**					
					w′pw	**0.18**	**0.31**	**0.44**	**0.56**					
					w′ s	**0.11**	**0.18**	**0.26**	**0.33**					
					w′ p	**0.58**	**0.97**	**1.35**	**1.74**					
					E′ e	**0.21**	**0.35**	**0.49**	**0.63**					
M	**0.6**	**1.0**	**1.4**	**1.8**	***r′ M***	**0.71**	**1.19**	**1.67**	**2.14**	***x′*M**	**0.11**	**0.19**	**0.27**	**0.34**
S	**0.0**	**0.0**	**0.0**	**0.0**	***r′ S***	**-0.09**	**-0.16**	**-0.22**	**-0.29**	***x ′*S**	**-0.095**	**-0.16**	**-0.22**	**-0.29**
A	**-3.2**	**-5.4**	**-7.6**	**-9.7**	***r′ A***	**-3.69**	**-6.18**	**-8.6**	**-11.07**	***x′* A**	**-0.45**	**-0.75**	**-1.05**	**-1.35**
Q	**-0.4**	**-0.6**	**-0.84**	**-1.08**	***r′ Q***	**-0.39**	**-0.64**	**-0.9**	**-1.16**	***x′*Q**	**-0.019**	**-0.03**	**-0.04**	**-0.06**

Table 8: Long run adjustment

	% Price Change				*Output*				
Scenarios	1	2	3	4		1	2	3	4
M	0.6	1.0	1.4	1.8	*x′*M	0.71	1.19	1.67	2.14
S	0.0	0.0	0.0	0.0	*x ′*S	-0.09	-0.16	-0.22	-0.29
A	-3.2	-5.4	-7.6	-9.7	*x′* A	-3.69	-6.18	-8.61	-11.07
Q	-0.4	-0.6	-0.84	-1.08	*x′*Q	-0.39	-0.64	-0.90	-1.16