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# An Examination of Foreign Foot-and-Mouth Disease on the Export Market: The Case of U.S. Swine Meat Exports

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Food safety scares affect consumption behavior, and increasingly food safety and animal life issues are impacting international agricultural trade. This study examines how Foot-and-mouth disease (FMD) discoveries in other countries importing U.S. swine meat have impacted U.S. swine meat exports to these countries. Annual trade data for sixteen countries used in this study are derived from the FAS/USDA. This study proposes a gravity model with panel data fixed-effect regressions to analyze the effects of FMD in countries that import U.S. swine meat. The results show that the FMD outbreaks in foreign countries have a significant positive influence on U.S. swine meat exports. However, if FMD-affected countries had a consecutive FMD outbreak, U.S. swine meat exports would be impeded.

The increased concern for Sanitary and Phytosanitary (SPS) issues is one of the recent significant structural changes in international trade. The risk of foot-and-mouth disease (FMD) is one of the reasons leading to SPS measures that are applied to protect human or animal life or health from risks within the territory of the World Trade Organization member countries. Many researchers have investigated the economic impacts of FMD outbreaks (Paarlberg, Lee, and Seitzinger 2002; Paarlberg, Lee, and Seitzinger 2003). According to these research results, if an FMD outbreak happens in a country, domestic prices decrease, exports decline, producers' welfare decreases, and consumers' welfare could decrease or increase depending on their response to the FMD outbreak. In sum, FMD has a negative impact on supply and demand within a country. Rushton (2009) mentioned that the incentives to achieve FMD-free status for countries with the potential to export meat are high. When a country remains disease-free, does it lead to higher potential exports? This study tests all FMD-affected countries that had an increase or decrease in U.S. swine meat exports.

This study focuses on the impacts of FMD in foreign markets on U.S. swine meat exports. FMD outbreaks alter the short-run supply and demand structure in a country. The impacts on supply and demand from an FMD outbreak should have different durations, because animal production can take

a long time, even more than one year, but meat demand may go back to original purchase levels in a few months. According to Roh, Lim, and Adam (2006), hog prices dramatically dropped after an FMD outbreak, but returned to the original level about three months later. Therefore it is possible that demand can go back to an original level within a year.

Historical data shows that the volume of U.S. exports of swine meat increased by about 200 percent from 1996 to 2005. Fuller, Fabiosa, and Premakumar (1997) found that the occurrence of FMD in Taiwan during 1997 is an important factor in explaining why the U.S. continues to increase and retain the major share of export opportunities. Seemingly, the change in U.S. swine meat exports has correlations with other countries' FMD occurrences. An important trade question is whether and how importing countries affected by FMD change their meat import decisions. The U.S. has not had an FMD outbreak since 1929, but it is important to understand the impact of foreign FMD-affected countries on U.S. swine meat exports.

## The Analytical Framework

### *Approach and Data*

Gravity models are widely used to examine bilateral trade flows. Formal theoretical foundations of the gravity models were provided in Bergstrand (1989). A previous study by Wilson and Otsuki (2004) reveals how to solve the puzzles of regulations, policies, and standards. The FMD outbreak issues in importing countries are considered food-scare issues that result in a serious impact on trade flows.

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Hence this study applies a gravity equation with panel data to find out whether other FMD-affected countries tend to increase swine meat imports from the U.S. The panel is tested for fixed or random effects by using the Hausman specification test.

The data on FMD outbreaks was derived from the OIE website (OIE n.d.). From 1996 to 2005 there were more than 15 countries affected by FMD outbreaks, and many of them were among U.S. major swine meat trade partners (OIE n.d.). The trade data used in this analysis were derived from the USDA Foreign Agricultural Service BICO Export Statistics (USDA-FAS n.d.). FAS reports on swine meat trade contain aggregate and country-specific data for exporting volume and value. From the U.S. Trade Exports, meat of swine (aggregate) coded HS-0203 is selected, which includes meat of swine in fresh, chilled, and frozen form. Annual U.S. export value and volume data were picked from the countries that have had FMD outbreaks from 1996 to 2005. Overall, 16 FMD-affected countries and regions were included: Brazil, Bulgaria, China, Colombia, Ecuador, France, Greece, Hong-Kong, South Korea, Malaysia, Philippines, Russia, Thailand, Taiwan, United Kingdom, and Venezuela.

### The Model and Econometric Specifications

Following the gravity model, exporting equations are derived by taking the double logarithm of economic variables. The gravity model allows us to add some dummy variables, such as FMD. The specification of the general gravity equation for our model is

$$(1) \ln Exports_{i,t}^x = \gamma_0 + \gamma_1(FMD_{i,t}) + \gamma_2(lagFMD_{i,t}) + \gamma_3(CFMD_{i,t}) + \gamma_4(GDP_{i,t}) + \gamma_5 \ln(Distance_i) + \gamma_6 \ln(RER_{i,t}) + \gamma_7 \ln(WTO_i) + \varepsilon_{i,t},$$

where  $i$  stands for the U.S. swine meat imports and  $t$  denotes time. The definitions and summary statistics of the dependent and independent variables are shown in Table 1. Our model is estimated for two different dependent variables: annual volume and value of U.S. exports. Therefore the superscript  $x$  of  $\ln Exports_{i,t}^x$  represents either volume (Q) or value (\$). The  $Exports_{i,t}$  represents the amount of swine meat that the U.S. exported to individual  $i$  countries in a particular year  $t$  for the years 1996–2005. This

study assumes the error  $\varepsilon_{i,t}$  to be normally distributed with a mean of zero.

$FMD_{i,t}$  reflects the presence of FMD outbreaks in country  $i$  at a particular time  $t$ , which is reported and recorded by the OIE (n.d.).  $LagFMD_{i,t}$  represents a one-year lag of the presence of FMD outbreaks in country  $i$  at time  $t$ . Both coefficients of  $FMD$  and  $lagFMD$  are expected to have positive signs because we expect that FMD-affected countries import more swine meat in a year in which FMD outbreaks occurred.  $CFMD_{i,t}$  takes a value of 1 at a particular time  $t$  if country  $i$  has different FMD outbreaks in years  $t-1$  and  $t$ , and 0 otherwise. This variable is important because some countries in the data set had different FMD outbreaks in consecutive years. The  $FMD$  and  $lagFMD$  variables alone do not give information about continuous shocks from FMD, and a continuous shock has different impacts from the shock of  $FMD$  and  $lagFMD$  on U.S. swine meat exports. The result of  $CFMD$  shows how importing countries react when consecutive or different FMD outbreaks occur. The coefficient of  $CFMD$  is expected to be negative due to continuous depression in supply and demand sides.

$GDP_{i,t}$  is introduced as a proxy of importing countries' swine meat demand, and is measured by the real per capita GDP for each swine meat importing country  $i$  in 2005 U.S. dollars. In countries with a good living standard, people tend to purchase more, so we expect that GDP per capita is a positive sign.  $Distance_i$  is the geographical measure of distance from the nearest harbor of the United States to that of importer countries. A farther distance implies more cost to transport product, so a negative sign is expected.  $RER_{i,t}$  is the annual average real effective exchange rate between the U.S. dollar and the domestic currency of each importing country. An appreciation in the U.S. dollar means depreciation in the foreign currency, leading importing country to purchase less because their currency has a lower purchasing power. Thus we expect negative coefficients of  $RER$ .  $WTO_i$  takes a value of 1 if the importing country is a member of the World Trade Organization (WTO). Since the U.S. is the member of WTO, we expect a positive sign if U.S. swine meat importers are also the member of the WTO.

**Table 1. Definitions of Variables and Sample Statistics, 1996–2005.**

Variables	Variable description	Mean	Std dev
Dependent variables			
$Exports_{i,t}^Q$	Annual volume of U.S. swine meat exported to country <i>i</i> (metric tons)	5414	9605
$Exports_{i,t}^S$	Annual value of U.S. swine meat exported to country <i>i</i> (\$1,000 dollars)	8841	17247
Independent variables			
$FMD_{i,t}$	Dummy variable for occurrences of FMD outbreaks in this year gets 1; otherwise 0	0.3812	0.4872
$lagFMD_{i,t}$	Dummy variable for occurrences of FMD outbreaks in last year gets 1; otherwise 0	0.3375	0.4743
$CFMD_{i,t}$	Dummy variable for continuous occurrences of FMD outbreaks in last and this year gets 1; otherwise 0	0.2187	0.4146
$GDP_{i,t}$	Real per capita country <i>i</i> GDP (U.S. \$)	10270	10510
$Distance_i$	Geographical distance between the U.S. and country <i>i</i> (miles)	5988	2838
$RER_{i,t}$	Real effective exchange rate between U.S. \$ and domestic currency <i>i</i> (value of one dollar in terms of domestic currency <i>i</i> )	235	633
$WTO_i$	Dummy variable for WTO member countries: Brazil, Bulgaria, China, Colombia, Ecuador, France, Greece, Hong-Kong, South Korea, Malaysia, Philippines, Thailand, Taiwan, United Kingdom, and Venezuela	0.8625	0.3454

## Empirical Results

The empirical results are presented in Table 2. Due to the time-invariant variable, the Hausman specification test of the fixed or random effects in the panel data could not be performed. However, the correlation between the fitted values ( $xb$  in stata) and country-specific effects ( $u_i$  in stata) is never smaller than  $-0.08$ , so the random-effects model is rejected. Therefore the fixed-effects model for panel data is applied. The findings of coefficients in  $FMD$ ,  $lagFMD$ ,  $CFMD$ ,  $RER$ , and  $WTO$  in Table 2 show that the fixed-effects estimates of the gravity models have expected signs and significance levels.

The coefficients of  $FMD$  and  $lagFMD$  reveal a consistent positive sign. When importing countries were affected by FMD outbreaks, these 16 countries on average responded by importing more swine meat from the U.S. during the next year. The coef-

ficients of these two variables in value of exported swine meat are 0.6067 and 0.7286, respectively; the dynamic FMD effect ( $FMD$  plus  $lagFMD$ ) is 1.3353 in exporting value and 1.2271 in exporting volume. A way to transform the coefficient of a dummy variable to a percentage change in a log-linear model is to calculate the odds ratios ( $e^{x_i \gamma_i}$ ). The percentage change of FMD in value of exported swine meat is 83% (calculated from  $e^{0.6067} - 1$ ) with other variables being constant. Table 3 presents the corresponding percentage changes for the  $FMD$ ,  $lagFMD$ , dynamic  $FMD$ , and  $CFMD$  effects. From our value-exported model, the coefficient ( $\gamma_1$ ) of FMD is 0.6067;  $e^{0.6067} = 1.83$ , so in time  $t$  when an FMD outbreak occurred in a swine meat importing country, the value of U.S. swine meat exports increased by 83 percent, with a 75 percent increase in volume on average (all other factors being held constant). Using the same calculation for the dynamic FMD effect, an incidence of

**Table 2. Gravity Model Estimates of FMD-Affected Countries' Impacts on U.S. Swine Meat Exports, 1996–2005 (n = 160).**

	Value of exported swine meat	Volume of exported Swine meat
FMD	0.6067*	0.5614**
lagFMD	(0.29) 0.7286***	(0.26) 0.6657***
CFMD	(0.23) -0.8549	(0.19) -0.8472*
GDP	(0.52) 1.0058	(0.47) 1.3201
Distance	(1.88) Dropped	(1.85) Dropped
RER	-1.4647*** (0.47)	-1.3555** (0.56)
WTO	1.5059*** (0.48)	1.5919*** (0.53)
Rho $\rho$	0.95	0.94
Corr( $u_i$ , $x_b$ )	-0.9041	-0.9023
R <sup>2</sup> -within	0.15	0.14
R <sup>2</sup> -between	0.21	0.22
R <sup>2</sup> -overall	0.14	0.15
F-test	18.42	6.62

Value in parentheses are standard errors.

\*\*\*, \*\*, and \* statistically significant at the 1%, 5%, and 10% levels, respectively.

FMD outbreaks in an importing country dynamically increased the U.S. export of swine meat by 280 percent in value and 241 percent in volume on average. The variable *CFMD* shows significant impacts on trade volume, and the coefficient reveals an expected negative sign. When FMD outbreaks occurred in a swine meat importing country in years  $t-1$  and  $t$  consecutively, the volume of U.S. swine meat exports decreased by 57 percent on average (all other factors being held constant).

Previous literature found that FMD causes a negative impact on the importing country's supply and demand. Theoretically, if the supply impact were longer lasting than the demand impact, importers would tend to increase swine meat imports due to a shortage of volume. Although this study

is not able to confirm which impacts in supply and demand last longer, swine meat imports from the U.S. show a positive increase when swine meat importing countries have an FMD outbreak. This seems to imply that the negative supply shock is longer than the demand shock. This is similar to the findings in Roh et al. (2006).

Of all the economic variables such as *GDP*, *Distance*, and *RER*, only the coefficients of *RER* reveals an expected sign at the five percent significance level. A negative sign for *RER* is in line with hypothesis that people tend to purchase more U.S. swine meat if there is a depreciation of U.S. dollar. If the real exchange rate goes down by one percent (foreign currency appreciation), U.S. swine meat exports will increase by 1.35 percent in both

**Table 3. FMDs Effects on U.S. Swine Meat Exports.**

Variables	Value of exported swine meat		Volume of exported swine meat	
	Coefficients	% change	Coefficients	% change
FMD	0.6067	83	0.5614	75
lagFMD	0.7286	107	0.6657	94
Dynamic FMD Effects	1.3353	280	1.2271	241
CFMD			-0.8472	-57

value and volume. The estimation of geographical distance is automatically dropped because of the time-invariant variable. *GDP* did not show significant difference from zero. The regional trade agreement variable, *WTO*, is significant at the one percent level. The coefficient of *WTO* has the expected sign. This indicates that the U.S. has a greater chance to increase exports of swine meat to U.S. importing countries which are also *WTO* members.

Overall, the results of the gravity model with fixed effects show a fundamental significant effect and confirm the results of FMD effects on swine meat importing countries. FMD-affected importers tend to import more swine meat from the U.S. on an annual basis. Therefore each country has different issues with FMD effects and reacts differently from the others due to country economic mass, different regional trade agreements, or the distance to the U.S. In sum, the FMD issues in these importing countries confirm that U.S. swine meat exporters have a greater chance of exporting to those FMD-affected countries.

### Conclusions and Discussions

FMD outbreaks were spread throughout many countries in which the international swine meat market share was reorganized. This study investigates the impacts on the swine meat trading partners of FMD-infected countries. The estimated results confirms that the impacts from the trading partners of FMD-infected countries resulted in increased swine meat imports from the U.S. However, if FMD-affected countries had consecutive FMD outbreaks, U.S. swine meat exports would be impeded.

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