The Impact of Foot-and-Mouth Disease Vaccination Policy in Importing Countries on U.S. Swine Meat Exports

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Abstract

Our previous research found that FMD outbreaks in foreign countries have a significant positive influence on U.S. swine meat exports. However, not all of these FMD-affected countries adopted the same treatment policy to ease domestic FMD issues. This study proposes a gravity model with fixed-effect regressions to analyze the effects of FMD in countries that import U.S. swine meat. Annual trade data for seventeen countries are used in this study. This study confirms that different policies change the results from FMD. FMD-affected countries which adopted a vaccination policy have negative impacts on U.S. swine meat exports, and the estimated results did confirm that these seven countries are still very important swine meat markets for the U.S.

***Key words*:** international agricultural trade, Foot-and-Mouth Disease, vaccination policy, livestock

Introduction

The increased concern for Sanitary and Phytosanitary issues is one of the recent significant structural changes in the 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. A serious FMD outbreak can create tremendous negative impacts on domestic production, animal health, and economic activity. FMD is probably the livestock disease with the greatest economic impacts because FMD is contagious and has high morbidity (Rushton, 2009). Therefore, FMD-free countries usually adopt a zero-tolerance policy to avoid the intrusiveness of FMD.

Between 1996 and 2005, many countries were affected by FMD, as recorded by the World Organization for Animal Health (OIE). According to this record, most countries adopted a stamp-out policy (slaughter animals) to deal with FMD issues; others adopted a vaccination policy. Yang and Saghaian (2009) found that FMD outbreaks in swine meat importing countries could create an advantage for U.S. swine meat exports because the U.S. is FMD-free. However, different countries deal with FMD outbreaks by different treatment policies. Do these different treatment policies lead to an identical impact on the exporting market of the U.S.?

The objective of this study is to investigate whether the impacts on U.S. swine meat exports depend on FMD treatment policy in importing countries. Hence, this study examines two sample sets. The first sample set, which represents all U.S. importing countries with FMD outbreaks, tests and confirms whether the results are same as Yang and Saghaian (2009). The second sample set, which represents a subset of the overall

FMD sample set, is used to evaluate the impacts on U.S. swine meat exports if FMD-affected countries adopt a vaccination policy.

Many researchers have investigated the economic impact of FMD outbreaks (Paarlberg, et al., 2002; Thompson et al., 2002; Paarlberg, et al., 2003; Jarvis, et al., 2005; Roh, et al., 2006; Pendell, et al., 2007; Paarlberg, et al., 2008). From that research, if an FMD outbreak happens in a country, then domestic prices decrease, exporters lose, producer welfare decreases, and consumer welfare could decrease depending on the country's response to the FMD outbreak. In sum, FMD causes a negative impact on supply and demand within a country.

FMD outbreaks alter the supply and demand structure in the short-run for a country. The impact from an FMD outbreak should have a different impact between supply and demand. A country's animal production takes more than one year to return the original level after an outbreak, but meat demand may return to its original level in a few months. According to Roh, et al. (2006), hog prices dramatically dropped after an FMD outbreak in South Korea, and about three months later the hog prices returned to their original level. South Korea adopted a slaughter policy. Therefore, it is possible that demand can revert to its original level within a year, which leads to an increase in meat imports.

However, some countries have a vaccination policy that leads to a circumstance where the domestic supply shock does not alter quantity much. The question is what happens on the demand side. A vaccination policy is usually problematic, because FMD is highly contagious. An aggressive slaughter policy can effectively ease the FMD outbreak issue. Hence, the demand side under a vaccination policy should take longer to get back to the original level than a slaughter policy. If the demand side under a vaccination policy takes longer than a year to return to the original level, there should be a negative impact on U.S. swine meat exports.

The Analytical Framework

Approach and Data

Gravity models are widely used to examine bilateral trade flows. Previous studies by Peridy et al. (2000), Wilson and Otsuki (2001), Otsuki et al. (2001), and Anders and Caswell (2009) reveal how to solve the puzzles of regulations, policies, and standards. The FMD outbreak issues in importing countries are considered a food scare issue that results in a serious impact on trade flows. Hence, this study applies a gravity model to find out whether other FMD-affected countries intend to increase swine meat imports from the U.S.

To set up a gravity equation, this study assumes a CES utility function. Following Feenstra (2004), we let C^{ei} denote the pork consumption of importer *i* from an exporter *e*. This study assumes products are homogeneous so that the amount of imports of country *i* is the difference between domestic supply and demand. The utility function for country *i* is:

$$U(C^{i}) = \sum_{e=1}^{C} N^{e} (C^{ei})^{\sigma-1/\sigma} \qquad (1)$$

in which N^{e} denotes an array of products imported from country *e*. The representative consumer in country *i* maximizes his/her utility function subject to a budget constraint:

$$Y^{i} = \sum_{e=1}^{C} N^{e} (P^{ei})(C^{ei}) \qquad (2)$$

where P^{ei} denotes the price level in importing country *i* and can be written as:

$$P^{ei} = T^{ei} * P^{e} \quad (3)$$

(T^{ei} is transportation cost or tariff cost; P^{e} is the price level in exporting country e). When the importing consumer optimizes utility according to the budget constraint, the expression for the optimal consumption of each product is:

$$C^{ei} = \left({P^{ei}}/{P^{i}} \right)^{-\sigma} ({Y^{i}}/{P^{i}}) \quad (4)$$

in which P^{i} refers to importing country i's price index and can be expressed as:

$$P^{i} = [\sum_{e=1}^{C} N^{e} \left(P^{ei}\right)^{(1-\sigma)}]^{1/(1-\sigma)}. \quad (5)$$

According to Feenstra (2004), the total value of exports from country *e* to country *i* is:

$$X^{ei} \equiv N^{e} P^{ei} C^{ei}. \quad (6)$$

Hence, substituting equation (4) into (6), we obtain:

$$X^{ei} = N^{e} Y^{i} \left({P^{ei}}/{P^{i}} \right)^{1-\sigma}. \quad (7)$$

N^{e} is unobservable, but Feenstra (2004) indicates that one can use zero-profit conditions to solve this problem. Hence, the GDP in country *e* can be described as: $Y^{i} = N^{e} P^{e} \bar{y}$ which, when substituted into equation (7), results in the gravity equation:

$$X^{ei} = \left(\frac{Y^{e} Y^{i}}{(P^{e})^{\sigma} \bar{y}} \right) * \left(\frac{T^{ei}}{P^{i}} \right)^{1-\sigma} \quad (8)$$

where the X^{ei} is a dependent variable which represents the trade flows from country *e* to country *i*. On the right hand side of equation (8), income $Y^{e}\ or\ Y^{i}$ represents GDP per capita, T^{ei} is a measure for tariffs and transport costs, and country prices $P^{e}\ or\ P^{i}$ are measured with GDP deflators.

The gravity equation (8) represents an importing country whose import value or volume depends on their GDP per capita, the distance from exporters, and the price index differences with exporters. Although re-exports may happen, this study assumes that the amount of exports to the destination country equals the amount of imports from the U.S. Since the price index for each country is not available, this study uses real effective exchange rate, which contains GDP deflators. Transaction and tariff costs may not be fully observed, so this study uses the distance for a proxy of transaction costs. There are good reasons for arguing that country-specific effects may play a significant role. Therefore, this study uses a gravity equation with panel data. 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. From 1996 to 2005, there were more than 15 countries affected by FMD outbreaks, and many of them were among major U.S. swine meat importers. Each of these countries adopted different treatment policies to deal with FMD outbreaks; some adopted a vaccination policy, and others adopted a slaughter policy. For estimating the foreign FMD impacts to U.S. swine meat exports, swine meat importing countries that have had FMD outbreaks from 1996 to 2005 were selected. Overall, a sample set of seventeen FMD-affected countries was established: Brazil, Bulgaria, China, Colombia, Ecuador, France, Greece, Hong-Kong, South Korea, Malaysia, Netherlands, Philippines, Russia, Thailand, Taiwan, United Kingdom, and Venezuela. The sample set was further partitioned by creating a subset of seven FMD-affected countries that adopted a vaccination policy: China, Colombia, Hong-Kong, Malaysia, Philippines, Russia, and Taiwan.

The trade data used in this analysis were derived from the USDA Foreign Agricultural Service (FAS). FAS reports volume and value of U.S. swine meat exports by country. The data of U.S. swine meat exports, which coded HS-0203 in U.S. Trade Internet System, are selected and included meat of swine in fresh, chilled, and frozen form. Annual data of the U.S. export value and volume were used from 1996 to 2005. Data on GDP per capita and real exchange rate for each country were also obtained from USDA web site.

The Model and Econometric Specifications

This study uses an identical model to exam the seventeen- and seven-country sample sets. The first examination with the seventeen-country sample is to confirm whether this study could obtain similar results to Yang and Saghaian (2009). The second examination with the seven-country sample focuses on whether the impact of U.S. swine meat exports would differ if the FMD-affected importers adopted a vaccination policy.

The specification of the gravity equation for the seventeen-country sample is:

$$lnExports_{i,t}^{x} = \gamma_0 + \gamma_1(Time_t) + \gamma_2(FMD_{i,t}) + \gamma_3(lagFMD_{i,t}) + \gamma_4(CFMD_{i,t}) + \gamma_5 ln(GDP_{i,t}) + \gamma_6 ln(Distance_i) + \gamma_7 ln(RER_{i,t}) + \gamma_8 ln(POP_{i,t}) + \gamma_9 ln(Size_t) + \varepsilon_{i,t} \quad (9)$$

where *i* stands for the U.S. swine meat importers, 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 dependent variables: annual volume and value of exports. Therefore, the superscript x of $lnExports_{i,t}^{x}$ represents either volume (Q) or value ($). $Exports_{i,t}$ represents the amount of U.S. swine meat to exported individual *i* country in a particular year *t*. This study assumes the error $\varepsilon_{i,t}$ to be expected with mean zero. The variable $Time_t$ represents a linear time trend from one to ten years of observations.

The variable $FMD_{i,t}$ reflects the presence of FMD outbreaks in country *i* at a particular time *t*, which is reported and recorded by the OIE. The variable $lagFMD_{i,t}$ represents one year lag for an FMD outbreak in country *i* at a particular 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 as an FMD outbreak occurs. The variable $CFMD_{i,t}$ takes a value of 1 at a particular time *t* if country *i* has different FMD outbreaks in *t-1* and *t* year, and 0 otherwise. This variable is important in the analysis because some countries in the data set shown different FMD outbreaks in consecutive years. If we only have FMD and lagFMD variable, it does not give information about continuous shocks from FMD, and a continuous shock potentially has different impacts from the shock of FMD and lagFMD on U.S. swine meat exports. The result of CFMD shows how swine meat importing countries react when different FMD outbreaks occur, so the coefficient of CFMD is expected to be negative due to a continuous reduction in supply and demand.

$GDP_{i,t}$, is the importing country's real GDP per capita in 2005 U.S. dollars. When GDP is high, people purchase more pork, so we expect that the coefficient of GDP per capita is a positive sign. $POP_{i,t}$ is the population estimated in midyear (July/1st). An increasing population implies that the demand for pork should be larger, so we expect a positive sign on the coefficient of POP. $Distance_i$ is the geographical measure of distance from the nearest harbor of the United States to the importing country. A further distance implies more cost to transport the 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 of U.S. dollar would increase the importing country's price, so they would purchase less pork. Thus, we expect a negative sign on the coefficient of RER.

$Size_t$, a common variable in gravity models, is estimated as a proxy for the importance of the U.S. meat trade. We expect a positive sign on the coefficient of Size because the swine meat export is considered a relative important sector to U.S. agricultural trade. Size, as measured by total annual volume of swine meat trade of the U.S., may cause an endogeneity problem and potentially bias estimates. Our approach to exam the endogeneity issue is to introduce two instrumental variables, $Import_t$ and $Production_{t-1}$, for the variable Size. Instrumental variables must satisfy three properties: non-zero correlation with regressors, zero correlation with error term, and no direct effect on the dependent variable. $Import_t$ is total annual import trade value in goods and services of the U.S. $Production_{t-1}$ is the lagged total annual volume swine meat production of the U.S.

The seven swine meat importing countries that adopted a vaccination policy are a subset of the seventeen FMD-affected countries. The major purpose for the subset is to find whether FMD outbreaks cause a different impact on U.S. exports. Following the gravity model, the same key factors are included in equation (10). The specification of the gravity equation for the subsample is:

$$lnExports^{x}_{i,t} = \beta_0 + \beta_1(Time_t) + \beta_2(FMD_{i,t}) + \beta_3(lagFMD_{i,t}) + \beta_4(CFMD_{i,t}) + \beta_5 ln\left(GDP_{i,t}\right) + \beta_6 ln(Distance_i) + \beta_7 ln(RER_{i,t}) + \beta_8 ln(POP_{i,t}) + \beta_9 ln(Size_t) + \varepsilon_{i,t} \quad (10)$$

where *i* stands for the U.S. swine meat importer and *t* denotes time. For equation (10), the definitions of the dependent and independent variables are shown in Table 1 in which the summary statistics are different from seventeen FMD-affected countries. Equation (10) is also estimated for two dependent variables: annual volume and value of exports. Therefore, the superscript y of $lnExports_{i,t}^{y}$ represents either volume (Q) or value ($). $Exports_{i,t}$ represents that the amount of swine meat imported from the U.S. by country *i* in a particular year *t*. This study assumes the error $\varepsilon_{i,t}$ in equation (10) to be expected with mean zero. The variable $Time_t$ represents a linear time trend from one to ten years of observations.

The Variable $FMD_{i,t}$ in equation (10) has the same definition as in equation (9), which reflects the presence of FMD outbreaks in country *i* at time *t*. The coefficient for FMD in equation (10) is expected to have a negative sign. The supply shock in FMD-affected countries with vaccination policy should have a lower effect than in the seventeen-country sample. A vaccination policy for an FMD outbreak is problematic because FMD is highly contagious, and FMD outbreak issues always have a chance to return. If it takes longer than a year for the demand side to return its original level in vaccination countries, the vaccination decision will have a larger negative impact on U.S. swine meat exports, because the decision to import swine meat is highly dependent on the demand side. Hence, the coefficients of FMD and lagFMD are expected to be negative. Since we hypothesize for that it will take longer than a year for demand to return to its original level, the coefficient of CFMD is expected to be negative as well. The definitions and expected signs for coefficients on GDP, POP, Distance, RER, and Size are the same as equation (9).

The key economic variables in equation (9) and (10) are used in double-logarithmic form, which allows for the direct interpretation of coefficients as elasticities.

The other regressors are time and dummy variables. The elasticity defines the effect of a one percent change in the independent variable on the percentage change in dependent variable.

Empirical Results

Due to the time-invariant variable, the Hausman specification test of the fixed or random effects in panel data could not be performed for equations (9) and (10). However, the correlation between country-specific effects (u_i in Stata) and the fitted values (xb 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 to estimate equations (9) and (10). The estimation results are shown in Table 2 and 3, and the overall estimation are validated by the high F test. The estimates show that the heteroscedasticity problem exists, so this study applies the *vce(robust)* option in Stata, which provides robust standard-error estimates. The endogeneity concern on the variable Size is tested by introducing two instrumental variables, $Import_t$ and $Production_{t-1}$. The Hausman test for endogeneity on equation (9) shows that the IVs are valid and finds evidence of endogeneity for the variable Size at the 5% significance level against a two-sided alternative. In testing the over-identifying restriction, we have confidence in the overall set of instruments used.

The results of equation (9) are presented in Table 2. The findings for coefficients on lagFMD, GDP, Distance, and RER for equation (9) reveal the expected signs that are significantly different from zero. The result of lagFMD is in line with Yang and Saghaian (2009). The positive coefficients for lagFMD reveal that U.S. swine meat exports are rising for swine meat importing countries that are affected by FMD outbreaks. When swine meat importing countries are affected by FMD outbreaks, the response was to import more swine meat from the U.S. The coefficient (γ_3) for lagFMD is 0.5548 in value and 0.5536 in volume of exported swine meat.

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 ($e^{X_3 * \gamma_3}$). The percentage change of lagFMD in value of exported swine meat is 74% (calculated from $e^{0.5548} - 1$) with other variables being constant. Table 4 shows the corresponding percentage changes for each dummy variable for the seventeen- and seven-country models. An FMD outbreak in the previous year increases U.S. exports in both value and volume by about 74% on average. The coefficients for FMD and CFMD are not significantly different from zero in trade value and volume.

This result of equation (9) is in line with a priori expectations. Previous literature found that FMD causes a negative impact on the importing country's supply and demand. Therefore, the question becomes which negative impact lasts longer. Theoretically, if the supply impact were longer lasting than the demand impact, then importers would tend to increase swine meat imports due to a domestic shortage. Normally, the stamp-out policy leads to a substantial reduction in swine production, which would require more time to revert to the original supply level. Although this study is not able to verify whether supply impacts last longer than demand, the results for swine meat imports show a positive increase after an FMD outbreak. This seems to imply that the negative supply shock lasts longer than the demand shock (similar to the findings in Roh, et al. (2006)).

Of all the double-logarithmic coefficients, GDP per capita, Distance, and RER are the ones that are significantly different from zero and have the expected signs. A positive sign for GDP confirms the theory that when GDP is high, people purchase more pork. A one percent change in GDP per capita leads to a greater than three percent change in U.S. swine meat exports in both value and volume. A negative sign of the variable Distance shows that one percent change in nautical mile leads to a greater than seven percent decrease in U.S. swine meat exports for both value and volume cases. A negative sign of the variable RER is in line with theory that people intend 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 1.30 percent in both value and volume cases. The coefficients for POP and Size are not significantly different from zero.

The first stage validity of the Hausman test for endogeneity on equation (10) shows that the IVs are valid, but the test for the endogeneity of the variable Size cannot be rejected. This implies that the equation (10) do not have the endogeneity issue. The model set up is identical in equations (9) and (10), but loss in error degrees of freedom in the seven-country sample results in the failure of the endogeneity test. Losing degrees of freedom is probably a major issue here, so equation (10) applies the same IVs and estimations as equation (9). For both value and volume cases, the coefficients for the FMD variable reveal at the 5% and 10% significance level with negative sign which imply that swine meat importing countries with vaccination policy do negatively influence U.S. swine meat exports. However, the coefficients for lagFMD and CFMD are not significantly different from zero. The coefficient of FMD for value of exported swine meat is -0.6616, and for volume of exported swine meat is -0.5754. Using the same calculation for the dummy variables in log-linear model, the percentage changes from

FMD for countries adopting a vaccination policy are shown in Table 4. When a swine meat importing country adopted a vaccination policy, an FMD outbreak leads to a reduction in U.S. swine meat exports of 48% in value and 44% in volume.

In Table 3, the coefficients for the double-logarithmic variables for GDP per capita and Size turned out to be significant with the expected sign. The coefficient on GDP in Table 3 shows the same sign and a similar magnitude level with Table 2. The coefficient for Size is significant with an expected sign in Table 3. In other words, the seven-country that had a vaccination policy are still very important swine meat markets for the U.S. The coefficient on Time was negative and significantly different from zero, which means that some factors may highly correlate with time, and those factors have a negative impact on U.S. swine meat exports.

This study is not able to confirm which impacts last longer supply or demand. Whether the countries with vaccination policy imported more swine meat or not was totally dependent on their demand side. Since we found a negative impact on U.S. swine meat exports from these vaccination countries, it implies that demand may take longer than a year to return to its original level. The results of equation (10) show that U.S. swine meat exports may be reduced if swine meat importing countries adopted a vaccination policy. Comparing the results to Yang and Saghaian (2009), this study confirms that not all FMD outbreaks lead to an identical impact on U.S. swine meat exports. The impacts depend on the circumstance of the demand side in swine meat importing counties.

Conclusions and Discussions

The FMD problem does not exist in the U.S., but the impacts can be generated from trade partners that have FMD outbreaks. U.S. swine meat imports have increased significantly when importing countries were affected by FMD outbreaks. This result is in line with previous research findings (Yang and Saghaian, 2009). Overall U.S. swine meat exports volume has increased by over 210 percent from 1996 to 2005, and the U.S. is currently the first leading exporter. The increasing levels of U.S. swine meat exports may be related to foreign FMD outbreaks. This study also confirms that GDP per capita, distance, and real exchange rate are significant factors influencing U.S. swine meat exports.

The results of the second examination reveal that the U.S. experienced a significant decrease in swine meat exports when an importing country adopts a vaccination policy to resolve the FMD outbreak. This result confirms our earlier argument that exporting countries would have less meat exports if an importer adopted a vaccination policy. Specially, the seven-country that had a vaccination policy are still very important swine meat markets for the U.S.

The occurrence of FMD outbreaks in importing swine meat countries is one of the factors that has contributed to an advantage for U.S. swine meat exports. However, not all FMD outbreaks in swine meat importing countries present an identical impact on U.S. swine meat exports, especially when importing countries adopted different treatment policies. In sum, this study finds that the exporting countries, such as the U.S., do not always enjoy an increase in their exports to FMD-affected importing countries.

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Table 1. Definitions of variables and Sample Statistics, 1996 - 2005

Variables	Variable Description	Equation (9)		Equation (10)	
	Dependent Variables	Mean	Std. Dev.	Mean	Std. Dev.
$Exports^{Q}_{i,t}$	Annual volume of U.S. swine meat exported to country *i* (metric tons)	5127	9387.49	9243	10593.27
	⇨ With Variation		5611.33		6772.43
	⇨ Between Variation		7734.59		8735.25
$Exports^{\$}_{i,t}$	Annual value of U.S. swine meat exported to country *i* (thousand dollars)	8441	16809.63	13161	16565.84
	⇨ With Variation		10588.77		10285.41
	⇨ Between Variation		13417.49		13924.62
	Independent Variables				
$Time_t$	Time Trend 1996-2005	5.5	2.88	5.5	2.89
$FMD_{i,t}$	Dummy variable for occurrences of FMD outbreaks in this year gets 1; otherwise 0	0.3647	0.4827	0.50	0.5036
$lagFMD_{i,t}$	Dummy variable for occurrences of FMD outbreaks in last year gets 1; otherwise 0	0.3235	0.4692	0.4428	0.5003
$CFMD_{i,t}$	Dummy variable for continuous occurrences of FMD outbreaks in last and this year gets 1; otherwise 0	0.2058	0.4055	0.3142	0.4675
$GDP_{i,t}$	Real GDP per capita for country *i* (U.S. dollars)	11747	11796	6965	7103
$POP_{i,t}$	Population of country *i* (in thousands)	121575	291915	226969	431493
$Distance_i$	Geographical distance between the U.S. and country *i* (nautical miles)	4536	1567	5327	1220
$RER_{i,t}$	Real effective exchange rate between U.S. $ and domestic currency *i* (value of one dollar in terms of domestic currency *i*)	221	616	362	847
$Size_t$	Total annual volume of swine meat trade of the U.S. (metric tons)	759092	220891	759092	221831
$Import_t$	Total annual import value in goods and services of the U.S. (million dollars)	1382976	309174	1382976	310489
$Production_{t-1}$	One lag of total annual volume swine meat production of the U.S (metric tons)	1.1e+07	503157	1.1e+07	505297

Table 2: Gravity Model Estimates of FMD-Affected Countries' Impacts on U.S. Swine Meat Exports, 1996-2005

	Value of Exported Swine Meat	Volume of Exported Swine Meat
Time	0.5631	0.5216
	(0.45)	(0.45)
FMD	0.3735	0.3513
	(0.31)	(0.32)
lagFMD	0.5548**	0.5536**
	(0.26)	(0.25)
CFMD	-0.5473	-0.5926
	(0.36)	(0.37)
GDP	3.1652*	3.5013*
	(1.87)	(1.95)
Distance	-7.7654*	-9.2774**
	(4.18)	(4.30)
RER	-1.3238***	-1.965***
	(0.38)	(0.38)
POP	-4.9742	-6.2688
	(5.02)	(5.66)
Size	-5.7783	-5.2893
	(4.09)	(4.07)
Rho ρ	0.98	0.98
Corr(u_i, xb)	-0.9691	-0.9764
R^2-within	0.09	0.09
R^2-between	0.02	0.03
R^2-overall	0.01	0.02
F-test	22.43	21.34
Wald test (χ^2)	4022.36	3293.91

***, ** and * statistically significant at the 1%-, 5%-and 10%-level, respectively
The value in parenthesis reveals the standard error, and total observation number is 160.

Table 3: Gravity Model Estimates of FMD-affected Countries Adopted Vaccination Policy Impacts on U.S. Swine Meat Exports, 1996-2005

	Value of Exported Swine Meat	Volume of Exported Swine Meat
Time	-1.1047***	-1.1096***
	(0.40)	(0.37)
FMD	-0.6616**	-0.5754*
	(0.32)	(0.29)
lagFMD	-0.2504	- 0.2260
	(0.27)	(0.26)
CFMD	0.4556	0.3635
	(0.35)	(0.34)
GDP	4.4858***	4.2104***
	(1.41)	(1.49)
Distance	-3.7100	-3.8652
	(9.93)	(9.74)
RER	-0.1368	0.2582
	(0.44)	(0.44)
POP	6.1188	5.4018
	(4.56)	(4.81)
Size	9.0912**	9.4933***
	(3.83)	(3.55)
Rho ρ	0.98	0.98
Corr(u_i, xb)	-0.9672	-0.9538
R^2-within	0.33	0.34
R^2-between	0.14	0.21
R^2-overall	0.13	0.18
F-test	11.00	9.28
Wald test (χ^2)	9570.25	8080.80

***, ** and * statistically significant at the 1%-, 5%-and 10%-level, respectively
The value in parenthesis reveals the standard error, and total observation number is 70.

Table 4: FMDs Effects on U.S. Swine Meat Exports

Variables	Value of Exported Swine Meat		Volume of Exported Swine Meat	
	Coefficients	% change	Coefficients	% change
16-country				
lagFMD	0.5548	74%	0.5536	74%
7-country				
FMD	−0.6616	−48%	−0.5754	−44%