The Effect of Foot and Mouth Disease on Trade and Prices in International Beef Markets

Lovell S. Jarvis[a], José P. Cancino[b], and José E. Bervejillo[c]

Selected Paper prepared for presentation at the
American Agricultural Economics Association Annual Meeting
Providence, Rhode Island,
July 24-27, 2005

[a] Professor, Department of Agricultural and Resource Economics and Member, Giannini Foundation, University of California-Davis
[b] PhD Candidate, Department of Agricultural and Resource Economics, University of California-Davis
[c] Assistant Specialist, Agricultural Issues Center, University of California

The Effect of Foot and Mouth Disease on Trade and Prices in International Beef Markets

Lovell S. Jarvis, José P. Cancino, and José E. Bervejillo

Introduction

FMD is a highly contagious disease affecting cloven hoofed animals. An outbreak of FMD usually creates great economic damage. Accordingly, sanitary policy in importing countries is intended to avoid the introduction of FMD as a result of imported beef. During the second half of the 20th century, countries with endemic FMD were unable to export beef to countries that were FMD free unless the beef had been processed to inactivate the virus. The sanitary policy under which FMD free countries barred beef imports from countries with FMD was known as "zero tolerance" for FMD. As a result of the frequently severe restrictions on beef from FMD endemic countries, international beef markets were largely divided into an FMD free segment and an FMD endemic segment. Prices in the former were believed to be as much as 50 percent higher as in the latter (Jarvis, 1986**;** De las Carreras, 1993, 1995).

A number of FMD endemic countries, particularly Argentina and Uruguay, sought to eradicate FMD during the 1980s and 1990s to gain access to FMD free markets and their higher prices. Both countries succeeded in eradicating FMD in the late 1990s and temporarily gained access to the major FMD free markets in the Pacific Rim (US, Canada, Mexico, Japan and South Korea).[1] Contrary to expectation, anecdotal evidence from exporters suggests that export prices rose in each countries by only 10-15 percent (Bervejillo and Jarvis). The magnitude of these price increases suggests that the price

[1] Each country suffered new outbreaks of FMD in late 2000 and 2001. Uruguay is now FMD free with vaccination, while Argentina is free with vaccination in its most important beef producing areas.

differential between the FMD free and FMD endemic markets was lower than expected. While the shift in exports from the FMD endemic to the FMD free segments that occurred when Argentina and Uruguay gained access to FMD free markets might have somewhat lowered the pre-existing differential, the shift in exports seems too small to have reduced the differential so dramatically, judging from previous studies analyzing this possibility (e.g., Rae et al., Ekboir, et al.). However, during the last decade, a number of FMD free importing countries have adopted a sanitary policy allowing greater latitude for beef imports from countries in which FMD is being controlled by vaccination and this may also be a factor.

Traditionally, beef from countries that were vaccinating against FMD was not accepted in countries that were FMD free. However, by 1977 the European Union (EU) was accepting matured boneless beef from some countries where FMD had not been eradicated, provided there were no current outbreaks in the exporting country, all animals were dutifully inspected at slaughter, and beef was processed following accepted guidelines. This "minimum risk" sanitary policy had been adopted by the United Kingdom several years before (De las Carreras, 1993). The policy was based on scientific research showing that FMD virus can be carried in the bone and some other parts of a dead animal, but not in the muscle, since the pH of the muscle decreases naturally after death, inactivating the virus. The EU also began to accept beef from animals vaccinated against FMD, though it is clinically impossible with existing tests to differentiate between the antibodies in animals that have been infected with FMD as opposed to those vaccinated against FMD. The EU experienced no outbreaks as a result of importing such beef. The US then agreed to import beef under similar conditions during the Uruguay Round (Smith), as did Canada and several other importers.

The US provided Argentina and Uruguay with small tariff quotas in the mid 1990s. Additional beef could be imported at above quota tariff rates. After the 2001outbreak of FMD in the Southern Cone and the re-introduction of vaccination as a method for control, the U.S. and Canada stopped importing beef from the region. However, the U.S. and Canada resumed imports of Uruguayan beef once the country was judged free of disease outbreaks, even though Uruguay continued to vaccinate. This shows that under certain conditions large importers such as Canada and the US are now willing to accept beef from countries with ongoing vaccination against FMD. Under the regionalization principle accepted by US and Canada during the Uruguay Round, Argentina and Brazil may also gain access to those markets if they demonstrate that they can secure a region where vaccination is still practiced but where FMD outbreaks have not occurred for some time and where sanitary controls are in compliance with the importer nation requirements. Despite the presence of FMD in the northern states and the continued vaccination in all major beef exporting states, with the exception of Santa Catarina where vaccination has been banned, Brazil emerged as a leading beef exporter after 2000. These changes make it seem more likely that the price differential between the FMD free and FMD endemic markets could have shrunk.

Diakosavvas and Dries and Unnevehr found evidence of growing price co-integration in international beef markets, and Jarvis, Bervejillo and Cancino show that the prices of bone-in beef and boneless beef have been converging over the last two decades. When comparing the prices of FMD free (Australia and New Zealand) and FMD endemic

(Brazil and Uruguay) beef whose other characteristics appear similar, they also found evidence of price convergence, suggesting that the FMD differential has been shrinking. However, none of these studies specifically analyzed the effect of FMD on beef export prices.

This paper develops and uses a two step quantitative model to analyze the effect of Foot and Mouth Disease (FMD) on international beef markets over time. Using monthly data from 1990-2002 for 7 major beef exporters and for 22 major beef importers, we use a probit equation to estimate the probability that country i exports to country j, taking account of foot and mouth status of exporter, sanitary policy of importer, beef quality, trade preferences, distance, and other factors affecting whether beef trade occurs. We then use OLS to estimate the export prices that are obtained for beef, taking account of beef quality, country population, trading preferences, region, per capita income, and a time trend, including terms to adjust for censorship in the first stage. Using the estimated equations, we compare the predicted change in trading partners and in the prices received by the two exporters in our sample that are not FMD free, Brazil and Uruguay, under the assumption that their status switches from having FMD to being FMD free. The model performs well. The results suggest that FMD continues to impede trade between many countries and does accordingly reduce the price received for beef from countries with FMD. Nonetheless, the "sanction" from FMD appears smaller than previously believed.

Approach

Previous studies analyzing the effect of FMD on international beef trade have relied primarily on a simple comparison of the prices of beef exports from countries that are FMD free as opposed to FMD endemic (e.g., Jarvis; de las Carreras, 1993, 1995) to determine the price sanction, or on the inclusion of a dummy for FMD status of exporter as a determinant of the amount of beef traded between exporter and importer pairs (Koo, Karemera and Taylor). We are not aware of any effort to utilize regression analysis to determine the effect of FMD on export prices.

Our approach differs in several important respects. We utilize a two step process to estimate the effect that FMD status has on, first, the probability that trade occurs between exporter and importer pairs, and, second, conditional on trade occurring, on the price received in the markets to which beef is exported. Since FMD is not harmful to humans, one can hypothesize that consumers should be concerned only with quality characteristics other than the FMD status of the exporter. If so, the presence of FMD in an exporting country should impede access to foreign markets, but not affect the price at which beef of comparable quality sells when access is achieved. The price effect can then be measured by determining whether there is a significant differential between the price at which beef is sold in markets to which access is possible, given the presence of FMD, versus the price at which the same beef could be sold in markets to which access would be possible if FMD were absent.

We further hypothesize that, since exporting countries have exhibited different degrees of FMD “presence” and importing countries have imposed differing sanitary policies in the recent period, the effect of FMD on the probability that trade occurs between exporter and importer pairs is likely to vary according to specific exporter status and importer sanitary policy, i.e., in a more subtle manner than usually considered. If so, there is a potential gain to an exporter from reducing the perceived “infectious” quality of its beef, even if an FMD presence remains in the country. Similarly, there is a potential welfare gain to an importer who adopts a less restrictive sanitary policy, assuming that the policy adopted is equally effective in excluding FMD.

FMD status of exporter is included in the second stage to test the hypothesis that FMD has no independent impact on price as opposed to market access. Even if FMD presents no risk to humans, consumers or their importing agents could value beef less if they know of and are concerned about FMD as an aspect of quality. Alternatively, FMD status could be negatively correlated with unobserved quality differentials. For example, the historical presence of FMD could affect quality and this lower quality could be reflected in lower export prices.

Data Overview

Data was obtained for the seven major beef exporters regarding their export flows (quantum) and export receipts with each of their major trading partners.[2] The exporters and importers, along with their respective FMD status and/or sanitary policy during the period of analysis is shown in Table 1.[3] The number of trading partners per exporter ranged from 3 for Canada to 11 for Brazil. Collectively, and excluding EU intra bloc trade, these countries accounted for about 90 percent of world fresh beef trade in 2002. Beef is a heterogeneous product, with its unit value varying according to animal genetics, production technology, specific cut, whether it is sold bone in or boneless, and whether

[2] Sources of monthly data were: Statistics Canada, the Argentine Secretaría de Agricultura, Ganadería, Pesca y Alimentación, the Australian Bureau of Agricultural and Resource Economics (ABARE), the Brazilian Ministério do Desenvolvimento, Indústria e Comércio Exterior, the European Union EUROSTAT database, the New Zealand Institute of Economic Research (NZIER), the Uruguayan Instituto Nacional de Carnes, and the U.S. Department of Commerce. Some data are available online free of charge. Other data can only be obtained via services that charge a fee for a customized data set.

[3] As monthly data are currently available for Argentina only for 1998-2002, it was excluded from this analysis. We hope additional data will become available soon, permitting Argentina's inclusion in subsequent analysis.

fresh/chilled or frozen. Although most trade in beef 40 years ago was in carcass form, nearly all trade today occurs in the form of specific cuts. Different exporters sell different cuts to different importers, providing scope for variation in the observed price. We disaggregate beef trade according to four Harmonized Tariff Schedule (HTS) codes: chilled bone-in cuts (HTS 020120), chilled boneless cuts (HTS 020130), frozen bone-in cuts (HTS 020220), and frozen boneless cuts (HTS 020230).[4] Efforts to further disaggregate beef by higher digit codes proved impossible because different countries use different codes for specific cuts, which are not uniform across countries. We also attempt to adjust for beef that is grain fed as opposed to grass fed, as discussed below.

Using monthly data, we calculated the implicit beef export price for each exporter's beef products using the respective value of exports, divided by the total quantity of exports, as reported by each data source. Intra European Union trade was excluded. Each price series was deflated using the U.S. Producer Price Index (PPI) for all commodities. On average, chilled boneless cuts are the most valuable, followed by chilled bone-in cuts, with frozen bone-in cuts and frozen boneless cuts the least valuable and nearly equal in value. See Table 2. Although utilizing the four HTS codes to identify quality differences in beef is an improvement relative to aggregating beef into a single category, there is still a wide range of implicit prices for each of the four categories, indicating significant within-category heterogeneity.[5]

[4] As little trade currently occurs in carcasses, the other two six digit HTS codes corresponding to carcasses (HTS 020110 and HTS 020210) were discarded.
[5] The very high and the very low implicit prices include outliers that are usually the result of unusual transactions, e.g., very high prices received for small shipments. As these cases were rare and as there was no clear pattern among them, we chose to retain all observations.

We collected information regarding FMD status of exporter, trade policy of importer (FMD sanitary policy, tariffs and quotas), exporter and importer trade agreements, beef type (grass or grain fed), Gross Domestic Product (GDP), population, cattle stocks, and distance between main exporter and importer's port. Table 3 defines the variables and Table 4 contains key summary statistics for the data set.

The Model and Econometric Specifications

Prices are observed only when trade occurs. Because some countries do not trade, e.g., because they are too distant from each other or because FMD exists in the exporter and the importer will not import beef from exporters with FMD, we do not know the export prices that would occur if such trade occurred. We estimate the FMD effect on international prices by using a proxy for what would be the price that an FMD endemic country would obtain in a non-accessible market, utilizing a two step process. We first estimate a probit model to analyze the effect of FMD and other factors on whether country A exports to country B (probability of exporting equation). We then utilize OLS to estimate beef export prices (beef price equation) as a function of beef quality, variables thought to capture the effect of unobserved export quality differences, and trade preferential agreements, taking into account the potential for sample selection bias. In estimating the second step equation, we use the method generalized by Vella-Verbeek for panel data.

Probability of Export Equation

Following Harris and Loundes, we assume that the country's observed decision to export over time is the result of an exportability index, y_{it}^{*}. This index can be viewed as the excess export price offered to country i in period t (p_{it}^*), relative to its contemporaneous export reservation price (p_{it}). Thus,

$$y_{it}^* = p_{it} - p_{it}^*, \tag{1}$$

where i ($i = 1,\ldots,N$) denotes the country and t ($t = 1,\ldots,T$) denotes the panel. This index, which is not directly observed, will vary with country characteristics that affect both the domestic supply of and demand for beef exports in the specific country pair, Z_{it} . In addition to Z_{it} we also identify unobserved random country-specific export behavior over time, υ_{it} . This error term comprises random time-invariant country effects, ε_i , and random time and country variant effects, η_{it} , which are assumed to be independent across countries. This feature allows us to adequately account for any remaining unobserved heterogeneity across countries. Assuming that the exportability index is a linear function of each country's characteristics, we can derive the following reduced form latent regression model for a exporting country to engage in trade in each period,

$$y_{it}^* = Z_{it}\gamma + \upsilon_{it}, \tag{2}$$

where $\upsilon_{it} = \varepsilon_i + \eta_{it}$. Since we do not directly observe the difference $p_{it} - p_{it}^*$, but only the realization of y_{it} , such that the country exports if $y_{it}^* > 0$ and does not export otherwise, the selection criteria for each country is given by,

$$y_{it} = \begin{cases} 1 & if\ y_{it}^* = p_{it} - p_{it}^* > 0 \\ 0 & otherwise \end{cases} \tag{3}$$

where Z_{it} includes the exporter's FMD status, the importer's sanitary policy, and a number of variables that proxy other aspects of a reduced form net excess supply curve, e.g., GDP of exporter and of importer, human population of exporter and of importer, stock of beef cattle in exporting country and in importing country, beef quality (on the assumption that demand varies for different types of beef and that the cost of transportation varies by bone in and boneless beef and for chilled vs. frozen beef), and trade agreements existing between pairs of exporters and importers.

Denote u_i as the T vector of υ_{it} for country i. We assume

$$u_i \sim N.I.D.(0, \sigma_\varepsilon^2 ii' + \sigma_\eta^2 I) \tag{4}$$

Hence, for any country, the inter-temporal correlation ρ between error terms in successive periods is constant, i.e. $\rho = corr(\upsilon_{it}, \upsilon_{is}) = \sigma_\varepsilon^2 / \sigma_\varepsilon^2 + \sigma_\eta^2 \quad \forall\, t \neq s$.

Beef Price Equation

We assume that beef export price is a linear function of country characteristics such as beef quality, the exporter's and the importer's per capita GDP (which are correlated with the within-quality category price for both exporter and importer), trade agreements, a time trend, regional dummy, and FMD status. Thus,

$$p_{it} = X_{it}\beta + \omega_{it} \tag{5}$$

where $\omega_{it} = \mu_i + \nu_{it}$, i ($i = 1, \ldots, N$) denotes the country and t ($t = 1, \ldots, T$) denotes the panel. In equation 5 the error term includes a time-invariant country-specific component, μ_i, and a random time and country variant component, ν_{it}, which are assumed to be independent across countries. Denote w_i as the T vector of ω_{it} for country i. We assume

$$w_i \sim N.I.D.(0, \sigma_\mu^2 ii' + \sigma_\nu^2 I) \tag{6}$$

The beef export participation decision rule (equation 3) selects countries into observed classes (either in or out of the beef export market). As a result, the prices actually observed are not random samples of the population, but are instead truncated non-random samples. Therefore, the price equation must be estimated conditional on the outcome of the selection process in order to take into account the sample selection bias. We follow the procedure adopted by Ridder, and Nijman and Verbeek and generalized by Vella and Verbeek for panel data.

In the traditional Heckman two-step approach, to adjust for sample selection bias, the regression equation is augmented with an additional regressor that takes into account the correlation between the error terms in the probit and regression equations. In the panel data setting there are two error terms each in the probit and in the regression equations. Consequently two additional regressors (or bias correction terms) must be included. Consider the general form of censoring (the conditional expectations of the error terms in [4], given selection (i.e., positive exports)). The resulting bias in the observed means may be calculated as

$$E[p_{it} | y_{it} = 1] = X_{it}^{'}\beta + E[\mu_i | y_{it} = 1] + E[\nu_{it} | y_{it} = 1] \qquad (7)$$

We assume that the regressors from the probability of exporting equation [2] are strictly exogenous (not correlated with the error components). Given estimates of (2), which are reported in table 5, estimates of the two correction terms in (7) are constructed by numerical integration (see Vera-Toscano, Phimister and Weersink for further details on the estimation of these correction terms).

$$E[\mu_i | u_i^w] = \sigma_{\varepsilon\mu}\left[\frac{T}{\sigma_\eta^2 + T\sigma_\varepsilon^2}\overline{\omega}_i\right] \qquad (8)$$

$$E[e_{it} | u_i^w] = \sigma_{\upsilon\nu}\left[\frac{1}{\sigma_\eta^2}\omega_{it} - \frac{T\sigma_\varepsilon^2}{\sigma_\eta^2(\sigma_\eta^2 + T\sigma_\varepsilon^2)}\overline{\omega}_i\right] \qquad (9)$$

where $\overline{\omega}_i = 1/T\sum_{t=1}^{T}\omega_{it}$, $\sigma_{\varepsilon\mu}$ captures the correlation between the time-invariant country-specific effects and $\sigma_{\upsilon\nu}$ captures the covariance between the time-variant country-specific effects. The resulting estimated correction terms can be added to equation 5. We then estimate equation 5, including these correction terms, using OLS. The test for the significance of these terms is a test for non-response bias. This approach provides more economic insight into the processes driving the selection bias and helps identify the source of the heterogeneity (Jarvis and Vera-Toscano). Although two-step procedures are generally inefficient (Newey) the attraction of this approach, in contrast to maximum likelihood, is its relative computational ease. Further Vella and Verbeek's method provides initial consistent estimators for a LIML approach so that asymptotically efficient estimators can be obtained in one iteration.

Regression Results

Probability of Export Equation

We have an observation for each type of beef for each exporting country to each importing country in every month. As many exporters and importers do not trade with each other, many observations are zero (no trade). There are 30,576 observations, with trade observed in 16,505 cases. Although we observe trade in each of the four beef quality categories, there is significantly more trade in boneless cuts than in bone-in cuts, whether chilled or frozen. See Table 2.

We initially estimated the first equation so that the independent variables had the same effect on country i's decision to export to country j for each beef quality category. The estimated coefficients were nearly all as expected, but the model did not predict as well as desired. The results suggested that the effect of most independent variables on the decision to export differed by beef quality category. We thus re-specified the estimation equation accordingly. Unfortunately, we mistakenly omitted several terms. Although the results are good in terms of improving the model's ability to predict, we are hopeful that the preferred specification would have produced still better results. Estimation requires substantial time for convergence to be achieved. The version which we had hoped to report has been running for four days and we will not have time to report those results here. We therefore report preliminary results from the earlier specification and plan to update the paper with results from other runs later.

To help explain observed trade patterns, we included dummy variables for beef quality. These variables were expected to capture the 1) higher volume of trade in boneless as opposed to bone in beef cuts and 2) the lower cost and greater ability to ship beef that is frozen over longer distances. The omitted variable is HTS 020220, frozen bone-in beef. In the equation reported, the probability that trade occurs for beef in quality category 020220 is a function only of a constant term (it should also have been a function of each of the independent variables). See Table 5. The probability that trade occurs in quality category 020120 is again the same constant term, plus terms interacting each of the independent variables with the quality category 020120 (the probability that trade occurs in 020120 should have included the terms omitted for 020220). The probability that trade occurs in quality categories 020130 and 020230 should be specified as was category 020120. The misspecification should produce poorer results, especially for category 020220.

Each of the three beef quality dummy variables is highly significant. The estimated coefficients indicate a higher probability of trade for chilled bone-in and for frozen bone-in, cet. par., than for chilled or frozen boneless cuts. These results have no normative significance.

The effect of FMD on trade is captured through nine dummy variables. FMD status of exporter is classified as FMD endemic, FMD free with vaccination and FMD free, denoted X1, X2 and X3, respectively. Sanitary policy of importer is classified as zero tolerance, minimum risk, and open, denoted M1, M2 and M3, respectively. These variables allow for nine combinations: X1M1, X1M2, X1M3, X2M1, X2M2, X2M3, X3M1, X3M2, and X3M3. We do not have non-zero observations that fit the combination X2M1, so it is omitted. We then omit X1M1 and include the other seven combinations in the regression. Only 1 is non-zero for each observation.

We expected the probability of trade to be highest for exporters that are FMD free, regardless of the sanitary policy faced, as the FMD free exporters face no sanitary restrictions. Exporters who are FMD free with vaccination should not export to importers with a policy of zero tolerance. We indeed observed no such trade. Exporters that are FMD endemic should not export to importers with a policy of zero tolerance or minimum risk and thus the coefficients on X3M1 and X3M2 should also be large, negative and highly significant. The coefficients for the other FMD dummy variables have no particular importance, but are expected to be of ambiguous sign and probably not highly significant.

The results are partially consistent with expectations, but the lack of greater consistency may be due to the misspecification. In earlier regressions, the coefficients estimated on the FMD dummy variables followed expectations very closely. In this case, the coefficients on X1M2 are positive, large and highly significant, while the coefficients on X3M1 are negative and, for two categories, large and statistically significant. However, two of the coefficients on X3M2 are positive and statistically significant, which was unexpected. This may also be a problem of lags, since for example, Uruguay was exporting to the US when FMD broke out in 2000 and imports received in subsequent months are occurring when it was classified as FMD endemic, though it probably was not when the shipments began. Sixteen of 21 estimated coefficients are highly significant, indicating that FMD status is a major determinant of the probability of trade between countries.

We include distance from the main port of exporter to the main port of importer as a proxy for the cost of transportation, with greater distance expected to reduce the probability of trade. The square of distance is also included to account for expected-nonlinear effects. The coefficients on distance and on the square of distance are highly significant, but not necessarily of expected sign.

We include cattle stock of the exporter and of the importer. We assume that a higher cattle stock for the exporter will increase the probability of trade and a higher cattle stock for the importer will reduce the probability of trade. The coefficient on exporter cattle stock is negative and significant, while the coefficient on importer cattle stock is positive and mainly significant. Neither result is expected. In earlier regressions, both results were reversed.

We included several additional variables to help explain trade and thus reduce the likelihood of specification bias for the estimated coefficients on the FMD status variables. These variables are GNP of exporter and of importer, and population of exporter and of importer. The expected signs of these variables are not a priori clear. For example, a high exporter GNP could signify high domestic demand and thus a lower probability of trade, or a well developed beef industry that is more capable of supplying beef cuts that are desired by other countries.

The estimated rho, the inter-temporal correlation between error terms in successive periods, is positive and highly significant, indicating the importance of adjusting for such correlation.

Table 6 shows the matrix of correct and incorrect predictions. The first stage equation predicts correctly 79 percent of the time, with approximately equal proportional error across the four categories. Thus, although the specification omits several terms, it predicts trade well. The original specification for the first stage equation produced coefficients that were nearly all as expected, but as it did not predict trade as well, we have not used it here.

Beef Price Regression

The second stage equation attempt to explain the price of beef received by different exporters in different import markets. The equation is specified as follows:

P = f(beef quality, time trend, exporter per capita GDP, importer per capita GDP, interaction terms for beef quality and per capita GDP, a proxy for grain fed as opposed to grass fed beef, and a series of dummy variables reflecting regional conditions).

The predicted price for beef quality category 020220 is determined by using all of the estimated parameters in the fourth column. The predicted price for the other three beef quality categories are determined by using all of the estimated parameters in the fourth column as well (these terms affect the predicted price for each category), plus the estimated coefficients columns under the columns for each respective category.

We include a time trend to capture the well-known, longer-term tendency for the price of beef to decline (Delgado, et al). The estimated coefficient is negative and highly significant, as expected.

We hypothesized that grain fed beef would receive a higher price than grass fed beef. In part, this hypothesis was based on the expectation that grain fed beef was more costly and, at least in the US, Canada, Japan and Korea, was thought to receive higher prices. We also had noticed in a previous study that US export prices were consistently higher than those of any other exporter and we attributed this, at least in part, to the grain fed nature of US beef exports. We lack the ability to determine directly whether a specific shipment of beef is grain fed and instead proxy this quality by assuming that all beef exported from the US and from Canada is grain fed. We recognize that some beef from other countries is also grain fed. For example, approximately 30 percent of Australia's beef production and 25 percent of exports are of grain fed beef. Almost all of Australian exports of grain-fed beef are shipped to Japan (USDA), but we are unable to capture this by using HTS codes. Similarly, some beef in Uruguay and Brazil is "finished" on grain, though only a small proportion are grain fed and the feeding period for those animals is very brief compared to that commonly used in the US. With these strong caveats, we note that the empirical results do not support the hypothesis that grain fed beef receives a higher price. The coefficient on "beef exported from the US or from Canada (with export to Mexico excluded)" is consistently negative and statistically significant.

We included a number of other terms intended to capture regional effects. Prices received for sales to the EU are significantly the highest, with prices in middle income Asia next and, somewhat surprisingly, prices in high income Asia somewhat lower. Exports to the US and to Canada are somewhat above average, but not high. This may reflect the tendency to import manufacture beef, but of high quality with respect to other characteristics. Exports to the Southern Cone countries (Argentina, Brazil, Chile, and Uruguay) receive somewhat lower than average prices; this may occur because three of them are major beef exporters and all are members of the same free trade area. Beef exported to the other middle income countries also receives somewhat lower prices, presumably because they demand beef of lower quality.

We expect that price should vary with beef quality. Table 7 defines the variables considered in the price equation. As shown in Table 8, the coefficients on the three beef quality dummy variables ("HTS") are positive and highly significant, indicating that disaggregating according to beef quality category has the expected effect.

The EU provides Argentina, Brazil and Uruguay each with a special quota for high quality cuts (020130), informally called the Hilton Quota as the beef is intended for purchase by restaurants and hotels. However, exports through the Hilton Quota are mixed in with general exports in the 020130 category and the estimated coefficient for Uruguay is negative, rather than positive as expected.

The FMD status of the exporter was included to determine if FMD has a direct impact on price, independently of whether it affects the exporting country's access to different markets. The model indicates that FMD does have a strong negative direct effect, equal to 15 to 30 percent of the base price, for three of the categories. FMD does not appear to have a direct price effect for category 020220; the coefficient is negative, but not significant.

Because of the large price variation within each beef category, we include per capita income in exporter and in importer as a supply and a demand proxy to capture some of this variation. We also interacted per capita GDP with beef quality to determine if the effects of income on quality varied by beef quality category. In each case, the estimated coefficients are highly significant, though the signs vary from positive to negative. The effort here is to improve the precision of the price prediction.

The two-step estimator for panel data selection breaks down the selection into two separate selection (correction) terms, $a1_i$ and $a2_{it}$. The inclusion of the correction terms accounts for the endogeneity of the export (participation) decision and, as the decision not to export corresponds to zero price, their inclusion also accounts for the selection bias from estimating over the sub-sample with positive trade. The estimates of these parameters indicate whether the endogenous sample selection is due to time-invariant ($a1_i$) or time-variant ($a2_{it}$) factors. Selection into the beef export market has a country specific component, $a1_i$ (which reflects export price differences across countries), and an "idiosyncratic" component, $a2_{it}$ (which reflects export price differences over time for a given country). Both correction terms are statistically significant, indicating that both forms of endogeneity/selectivity are present and, therefore, justify the approach followed. The positive sign on $a1_i$ indicates that the time-invariant unobserved country effects in the market participation and price equations are positively correlated (i.e. the unmeasured time-invariant factors that make countries more likely to export have a positive effect on the export price level). For example, if the random effects reflect unobserved cultural links, these links will increase the probability of trade and increase the export price. The positive sign on $a2_{it}$ implies that over time, for a given country, the time-varying factors that increase the probability of trade make the exporter likely to face a higher export price. For example, if the random effects reflect an unobserved improvement in quality that increases the probability of trade, it has increased the export price as well.

The overall fit of the equation is good for this sort of equation, with the adjusted R^2 being 0.33.

Prediction and Simulation

Based on the estimated probability of export and beef export price equations, we concluded that FMD status has a negative impact on the probability of export and the beef export price. We seek to predict the effect of FMD on trade flows and international beef prices. In this study, we cannot estimate the equilibrium effects of changes in trade. However, previous studies generally have not had good impact estimates of how changes in exporting country FMD status (or in the sanitary policy of importing countries) might initially change market flows. We utilize the probability of exporting equation to predict trade flows, using exogenous variables as drivers of the results. Then, by assuming that Brazil and Uruguay, the main two exporting countries in our sample that are not FMD free, change their status to FMD free, we simulate the expected changes in trading relationships that result. We can also obtain a first order approximation to the price effects of changes in FMD status by simulating the prices that would occur for Brazil and Uruguay if their FMD status changed, contingent on their new trading relationships. The model simulates a price for each beef quality in each market in which each of the countries trade. We compare the distribution of these prices and the average of these prices with a) those that actually occur and b) those that our model predicts should occur under actual circumstances when neither country is FMD free.

The estimated equations were next used to quantitatively evaluate the difference between the prices obtained by traditionally FMD endemic countries (Brazil and Uruguay) under two scenarios: 1) Baseline scenario, where the probability of export equation was used to predict trade or no trade with their market destinations under their actual FMD status and the beef price equation was used to obtain the predicted price for all the exporter-importer combinations for which trade was predicted; and 2) FMD free scenario, in this case Brazil and Uruguay are considered as if they were FMD free. In the second scenario simulation, all probability determinants except Brazil and Uruguay's FMD status were set equal to their actual levels. However, the FMD status was assumed to be FMD free and the corresponding export probability and export price were simulated over time. The difference between the average annual export prices obtained for the above two scenarios gives the estimated impact of gaining FMD free status on the beef export price for Brazil and Uruguay.

The results are shown in Tables 9 and 10. For simplicity, only the results for boneless cuts are presented. These results predict that the gain from eradicating FMD are 4 percent and 19 percent for Brazil, for chilled and frozen boneless cuts, respectively, and 5 percent and 9 percent for Uruguay, for the same cuts. These are relatively small gains, at least when compared to the price differences commonly attributed to the FMD endemic and FMD free market segments.

Conclusions

The paper develops and uses a two step quantitative model to analyze the effect of Foot and Mouth Disease (FMD) on international beef markets over time. Using monthly data from 1990-2002 for 7 major beef exporters and for 22 major beef importers, we use a probit equation to estimate the probability that country i exports to country j, taking account of foot and mouth status of exporter, sanitary policy of importer, beef quality, trade preferences, distance, and other factors affecting whether beef trade occurs. We then use OLS to estimate the export prices that are obtained for beef, taking account of beef quality, country per capita, trading preferences, region, per capita income, and a time trend, including terms to adjust for censorship in the first stage. Using the estimated equations, we compare the predicted change in trading partners and in the prices received by the two exporters in our sample that are not FMD free, Brazil and Uruguay, under the assumption that their status switches from having FMD to being FMD free. The model performs well. The results suggest that FMD continues to impede trade between many countries and does accordingly reduce the price received for beef from countries with FMD. Nonetheless, the "sanction" from FMD appears smaller than previously believed.

These results warrant careful interpretation. Although we are pleased with the model's apparent ability to predict both trade between exporters and importers and the prices in different import markets, the results are static, not dynamic. For example, the model may predict that country i will export to a different set of importing countries following a change in FMD status, with the prediction being based on parameters that have been estimated from the existing set of trading relationships. The model does not allow for subsequent adjustment if the underlying parameters change as trading relationships change.

Similarly, the estimated price sanction caused by the existence of FMD in an exporting country is calculated as the difference between an average of all prices in the predicted trading sets for that country, assuming the country changes FMD status, plus the removal of the FMD price sanction in the beef price equation. However, even if a country were to change is trading relationships as predicted, it need not export the same amount to each trading partner. We would expect that it would export more to those markets in which a higher price is received. Nonetheless, we note that exports to the very high priced markets among current trading relationships are usually constrained by trade barriers, e.g., quotas or tariff quotas. Thus, the use of an average predicted price received among trading partners may not be a bad approximation of the actual price received.

References

Bervejillo, José E. and Lovell S. Jarvis. (Forthcoming) "Foot and Mouth Disease Eradication and Control in the Southern Cone." *Development Policy Review*

De las Carreras, Alberto. 1993. *La Aftosa en la Argentina. Un desafío competitivo*. Cámara Argentina de Consignatarios de Ganado, Buenos Aires.

De las Carreras, Alberto. 1995. "Implications for World Beef Trade of Changing Foot and Mouth Disease Status in Argentina and Other LatinAmerican Countries." OECD, Committee for Agriculture. AGR/CA/APM/MD (95)9.

Delgado, C., M. Rosegrant, H. Steinfeld, S. Ehui, and C. Courbois. 1999. *Livestock to 2020: The Next Food Revolution*. Food Agriculture and the Environment Discussion Paper No. 28, International Food Policy Research Institute, Washington, D.C.

Diakosavvas, D. 1995. "How Integrated are World Beef Markets?. The Case of Australian and U.S. Beef Markets." *Agricultural Economics*, 12: 37-53.

Dries, M.A. and L.J. Unnevehr. 1990. "Influence of Trade Policies on Price Integration in the World Beef Market." *Agricultural Economics*, 4: 73-89.

Ekboir, Javier, Jarvis, Lovell S., José E. Bervejillo, Daniel A. Sumner, and William R. Sutton. 2002. "Changes in Foot and Mouth Disease Status and Evolving World Beef Markets." *Agribusiness International Journal*, 18(2): 213-229.

Harris, M. and J. Loundes. 2000. "Dynamic Relationships in the Australian Labour Market: Heterogeneity and State Dependence." Melbourne Institute Working Paper No. 6/00. Melbourne Institute of Applied Economic and Social Research. The University of Melbourne. Victoria, Australia.

Jarvis, L.S. 1986. *Livestock Development in Latin America*. Washington, D.C.: The World Bank.

Jarvis, L.S. and E. Vera-Toscano. 2004. “Seasonal Adjustment in a Market for Female Agricultural Workers.” *Amer. J. Agr. Econ.* 86(1): 245–257.

Jarvis, L.S., J.E. Bervejillo and J.P. Cancino, “International Beef Prices: Is There Evidence of Convergence?” *Review of Agricultural Economics*. (Forthcoming).

Koo, W.W., D. Karemera and R. Taylor. 1994. “A Gravity Model Analysis of Meat Trade Policies.” *Agricultural Economics*, 10: 81-88.

Newey, W. “Efficient Estimation of Limited Dependent Variable Models with Endogenous Explanatory Variables.” *J. Econometrics* 36 (November 1987): 231-250.

Nijman, T. and M. Verbeek. “Nonresponse in Panel Data: The Impact on Estimates of Life Cycle Consumption Function.” *J. Appl. Econometrics* 7(July-September 1992): 243-257.

Rae, Allan N., Chris Nixon, and Peter Gardiner. 1999. "Foot-and-Mouth disease and trade restrictions: Latin American access to Pacific Rim Beef Markets." *The Australian Journal of Agricultural and Resource Economics*, 43(4): 479-500.

Ridder, G. “Attrition in Multi-wave Panel Data,” *Panel Data and Labor Market Studies,* J. Hartog, G. Ridder and J. Theeuwes, Eds. Amsterdam: Elsevier Science, 1990.

USDA. Australia Livestock and Products, Annual. *GAIN Report* (Various Issues), U.S. Department of Agriculture, Foreign Agricultural Service.

Vella, F. and M.Verbeek. “Two-step Estimation of Panel Data Models with Censored Endogenous Variables and Selection Bias.” J. *Econometrics* 90(June 1999):239-263.

Vera-Toscano, E., E. Phimister and A. Weersink. 2004. “Panel Estimates of the Canadian Rural/Urban Women’s Wage Gap.” *Amer. J. Agr. Econ.* 86(4): 1138–1151.

Smith, James F. 2003. “International Trade Agreements and Sanitary and Phytosanitary Measures.” In Daniel A. Sumner (Ed.), *Exotic Pests and Diseases. Biology and Economics for Biosecurity*, Iowa State Press, Ames, pp. 39-54.

Table 1. List of exporters and importers, along with their respective FMD status and/or sanitary policy 1990-2002

Country	Actual or assumed FMD status	Sanitary policy on imports
Exporters		
Australia	Free (Whole period)	n/a
New Zealand	Free (Whole period)	n/a
Exporters/Importers		
Brazil	Endemic (Jan-1990 to May-2000), Free with vaccination (Jun-2000 to Dec-2002)	Minimum risk (Whole period)
Canada	Free (Whole period)	Zero risk (Jan-1990 to Apr-1994), Minimum risk (May-1994 to Dec-2002)
EU	Endemic (Jan-1990 to Dec-1990), Free (Jan-1991 to Dec-2002)	Minimum risk (Whole period)
USA	Free (Whole period)	Zero risk (Jan-1990 to Apr-1994), Minimum risk (May-1994 to Dec-2002)
Uruguay	Endemic (Jan-1990 to Apr-1993; Aug-2000 to Nov-2000; May-2001 to Dec-2002), free with vaccination (May-1993 to April 95), free (May-1995 to Apr-2001)	Minimum risk (Whole period)
Importers		
Algeria	Endemic (Whole period)	None
Argentina	Endemic (Jan-1990 to Apr-2000; Aug-2000 to Oct-2000; Mar-2001 to Dec-2002), Free (May-2000 to Feb-2001)	Minimum risk (Whole period)
Chile	Free (Whole period)	Minimum risk (Whole period)
Egypt	Endemic (All period)	None
Hong Kong	Endemic (Whole period)	None
Iran	Endemic (Whole period)	None
Israel	Endemic (Whole period)	None
Japan	Free (Whole period)	Zero risk (Whole period)
Korea	Free (Whole period)	Zero risk (Whole period)
Malaysia	Endemic (Whole period)	None
Mexico	Free (Whole period)	Zero risk (Whole period)
Philippines	Endemic (Whole period)	None
Russia	Endemic (Whole period)	None
Saudi Arabia	Endemic (Whole period)	None
Singapore	Endemic (Whole period)	Minimum risk (Whole period)
South Africa	Endemic (Whole period)	None
Taiwan	Free (Jan-1990 to Dec-1996), Endemic (Jan-1997 to Dec-2002)	Zero risk (Whole period)
Turkey	Endemic (Whole period)	None

Table 2. Key Beef Export Price Characteristics ($/Metric Ton)

Type of Beef	Mean	Standard Deviation	Variance	Minimum	Maximum	Number of observations
Chilled bone-in (020120)	3,673.4	2,345.0	5,499,204.6	239.8	25,567.6	2,839
Chilled boneless (020130)	4,282.6	2,424.2	5,876,515.0	261.7	31,891.5	4,237
Frozen bone-in (020220)	2,650.5	1,801.6	3,245,738.7	123.4	17,514.5	3,665
Frozen boneless (020230)	2,613.9	1,388.9	1,928,959.9	125.2	24,025.9	5,764
All categories	3,232.6	2,091.3	4,373,513.1	123.4	31,891.5	16,505

Table 3. Key Sample Characteristics: variable definition and units

Variable	Definition and units
Q120	Dummy=1 if HTS=020120
Q130	Dummy=1 if HTS=020130
Q220	Dummy=1 if HTS=020220
Q230	Dummy=1 if HTS=020230
X1M2	Dummy=1 if exporter FMD free and importer applies minimum risk policy
X1M3	Dummy=1 if exporter FMD free and importer FMD endemic
X2M2	Dummy=1 if exporter FMD free with vaccination and importer applies minimum risk policy
X2M3	Dummy=1 if exporter FMD free with vaccination and importer FMD endemic
X3M1	Dummy=1 if exporter FMD endemic and importer applies zero risk policy
X3M2	Dummy=1 if exporter FMD endemic and importer applies minimum risk policy
X3M3	Dummy=1 if exporter and importer are FMD endemic
WDIST	Distance between main exporter and importer port, Thousands nautical miles
WDIST2	Distance square, Thousands squared nautical miles
XGDP	Exporter GDP, Trillions US$
MGDP	Importer GDP, Trillions US$
XPOP	Exporter population, Millions
MPOP	Importer population, Millions
XSTOCK	Exporter cattle stock, Millions
MSTOCK	Importer cattle stock, Millions
NAFTA	Dummy=1 if exporter and importer are members of NAFTA
MERCOSUR	Dummy=1 if exporter and importer are members of MERCOSUR
JAPKORE0	Dummy=1 if importer is Japan or Korea
JAPKORE	Dummy=1 if Australia, New Zealand or USA export to Japan or Korea
HILTON	Dummy=1 if Brazil or Uruguay export HTS 020130 to EU

Table 4. Key Sample Characteristics

Variable	Average	Standard Deviation	Variance	Minimum	Maximum
Q120	0.25	0.43	0.19	0.00	1.00
Q130	0.25	0.43	0.19	0.00	1.00
Q220	0.25	0.43	0.19	0.00	1.00
Q230	0.25	0.43	0.19	0.00	1.00
X1M2	0.16	0.36	0.13	0.00	1.00
X1M3	0.20	0.40	0.16	0.00	1.00
X2M2	0.03	0.17	0.03	0.00	1.00
X2M3	0.04	0.20	0.04	0.00	1.00
X3M1	0.03	0.18	0.03	0.00	1.00
X3M2	0.10	0.30	0.09	0.00	1.00
X3M3	0.12	0.33	0.11	0.00	1.00
WDIST	5.84	2.61	6.81	0.13	11.28
WDIST2	40.95	31.68	1,003.32	0.02	127.24
XGDP	2.13	3.31	10.94	0.01	10.38
MGDP	1.91	2.95	8.68	0.03	10.38
XPOP	120.73	133.44	17,806.10	3.11	379.74
MPOP	99.54	102.29	10,462.76	3.05	379.74
XSTOCK	65.53	61.41	3,771.24	8.03	185.35
MSTOCK	26.98	38.71	1,498.77	0.00	185.35
NAFTA	0.06	0.23	0.05	0.00	1.00
MERCOSUR	0.05	0.23	0.05	0.00	1.00
JAPKORE0	0.02	0.13	0.02	0.00	1.00
JAPKORE	0.01	0.11	0.01	0.00	1.00
HILTON	0.10	0.30	0.09	0.00	1.00

Table 5. Estimated Coefficients Random Effects Probit Estimation of Beef Export Market Participation.

	Type of Beef			
Variable	Chilled bone-in (020120)	Chilled boneless (020130)	Frozen boneless (020230)	Frozen bone-in (020220)
CON				-0.384 (0.000)
HTS	1.083 (0.000)	-0.087 (0.474)	0.716 (0.000)	
X1M2	0.757 (0.000)	0.913 (0.000)	1.213 (0.000)	
X1M3	-1.133 (0.000)	-0.421 (0.000)	0.521 (0.017)	
X2M2	0.448 (0.019)	1.446 (0.000)	1.261 (0.000)	
X2M3	-0.252 (0.160)	0.194 (0.118)	1.602 (0.000)	
X3M1	-0.045 (0.913)	-2.055 (0.000)	-2.271 (0.000)	
X3M2	-0.291 (0.109)	0.994 (0.000)	0.889 (0.000)	
X3M3	-0.919 (0.015)	-0.830 (0.000)	-0.183 (0.118)	
DISTANCE	-0.572 (0.000)	0.147 (0.000)	0.352 (0.000)	
$DISTANCE^2$	0.037 (0.000)	-0.029 (0.000)	-0.031 (0.000)	
XGDP	0.097 (0.010)	0.118 (0.000)	0.262 (0.000)	
MGDP	0.156 (0.000)	0.312 (0.000)	0.309 (0.000)	
XPOP	0.007 (0.000)	0.002 (0.003)	-0.005 (0.008)	
MPOP	-0.005 (0.000)	0.001 (0.182)	-0.008 (0.000)	
XSTOCK	-0.013 (0.000)	-0.002 (0.075)	0.005 (0.004)	
MSTOCK	0.001 (0.282)	-0.012 (0.000)	0.001 (0.708)	
HILTON		2.424 (0.000)		
ρ	0.750 (0.000)			
N=30,576; T=156				

p-values are in parenthesis.

Table 6. Number and Percentage of Correct and Incorrect Predictions

	Predicted trade	Predicted no trade
Actual trade	10,344 (33.8%)	6,161 (20.1%)
Actual no trade	2,591 (8.5%)	11,480 (37.5%)

Table 7. Variable Definition for Beef Export Price Equation

Variable	Definition and units
CONSTANT	Constant
XPCGDP	Exporter per capita GDP, Thousand of US$)
MPCGDP	Importer per capita GDP, Thousand of US$)
TREND	Time trend, time index = 1 to156
GRAINFED	Dummy =1 if exporter is Canada or USA (exports to Mexico are excluded)
HIASIA	High income Asia Dummy =1 if importer is Japan, Korea or Taiwan
MIASIA	Middle income Asia Dummy =1 if importer is Hong Kong, Malaysia, Philippines or Singapore
EURASIA	Dummy =1 if importer is Algeria, Egypt, Iran, Israel, Russia, Saudi Arabia, South Africa or Turkey
SCONE	Southern Cone Dummy =1 if importer is Argentina, Brazil or Chile
EU	Dummy =1 if importer is EU-15
CANUSA	Dummy =1 if importer is Canada or USA
HILTON	Dummy =1 if Brazil or Uruguay export to EU and HS=20130
HTS	Harmonized trade schedule
FMD	Dummy =1 if exporter is FMD free or FMD free with vaccination
FMD-HTS	Interaction FMD status and HTS
XPCGDP-HTS	Interaction exporter per capita income and HTS
MPCGDP-HTS	Interaction importer per capita income and HTS
a1i	Country-specific sample correction parameter
a2it	Country-specific overtime sample correction parameter

Table 8. Estimation of Beef Export Price Equation with Vella & Verbeek Correction

	Type of Beef			
Variable	Chilled bone-in (020120)	Chilled boneless (020130)	Frozen boneless (020230)	Frozen bone-in (020220)
CONSTANT				253.654 (0.048)
XPCGDP				102.818 (0.000)
MPCGDP				14.121 (0.000)
TREND				-9.469 (0.000)
GRAINFED				-175.921 (0.000)
HIASIA				1058.321 (0.000)
MIASIA				1590.391 (0.000)
EURASIA				69.492 (0.285)
SCONE				393.214 (0.000)
EU				2584.438 (0.000)
CANUSA				562.792 (0.000)
HILTON		-622.046 (0.000)		
HTS	1351.803 (0.000)	3143.981 (0.000)	1950.778 (0.000)	
FMD				-1.193 (0.994)
FMD-HTS	-986.416 (0.000)	-420.826 (0.035)	-527.985 (0.004)	
XPCGDP-HTS	-34.926 (0.000)	-91.912 (0.000)	-69.241 (0.000)	
MPCGDP-HTS	19.321 (0.000)	18.540 (0.000)	-20.400 (0.000)	
a1i	176.438 (0.000)			
a2it	370.738 (0.000)			
R^2	0.327			
N	16,505			

p-values are in parenthesis.

Table 9. Predicted Price Effect from Eradicating FMD ($/Metric Ton): Brazil

	Brazil							
	Chilled boneless				Frozen boneless			
Year	*FMD endemic*	*FMD free*	*Penalty%*		*FMD endemic*	*FMD free*	*Penalty%*	
1990	4,777	4,839	-1%	***	2,436	2,898	-16%	***
1991	4,675	4,737	-1%	***	2,304	2,767	-17%	***
1992	4,596	4,657	-1%	***	2,181	2,644	-18%	***
1993	4,457	4,538	-2%	***	2,075	2,538	-18%	***
1994	4,152	4,461	-7%	***	1,912	2,441	-22%	***
1995	3,991	4,412	-10%	***	1,789	2,352	-24%	***
1996	3,901	4,322	-10%	***	1,675	2,240	-25%	***
1997	3,793	4,214	-10%	***	1,595	2,158	-26%	***
1998	3,697	4,118	-10%	***	1,457	2,020	-28%	***
1999	3,580	4,001	-11%	***	1,289	1,853	-30%	***
2000	3,813	3,889	-2%	NS	1,514	1,749	-13%	***
2001	3,921	3,768	4%	***	1,618	1,618	0%	NS
2002	3,827	3,678	4%	***	1,492	1,492	0%	NS
All	4,091	4,280	-4%	***	1,795	2,213	-19%	***

** and *** denote differences that are statistically different from zero at the 5% and 1% level; NS denotes statistically insignificant. All corresponds to the average for 1990-2002.

Table 10. Predicted Price Effect from Eradicating FMD ($/Metric Ton): Uruguay

	Uruguay							
	Chilled boneless				Frozen boneless			
Year	*FMD endemic*	*FMD free*	*Penalty%*		*FMD endemic*	*FMD free*	*Penalty%*	
1990	4,599	5,020	-8%	***	2,243	2,641	-15%	***
1991	4,508	4,929	-9%	***	2,145	2,542	-16%	***
1992	4,437	4,858	-9%	***	2,123	2,440	-13%	***
1993	4,308	4,722	-9%	***	2,216	2,346	-6%	***
1994	4,336	4,596	-6%	***	2,250	2,250	0%	NS
1995	4,387	4,464	-2%	***	2,144	2,144	0%	NS
1996	4,329	4,329	0%	NS	2,042	2,042	0%	NS
1997	4,057	4,057	0%	NS	1,941	1,941	0%	NS
1998	3,964	3,964	0%	NS	1,836	1,836	0%	NS
1999	3,999	3,999	0%	NS	1,703	1703	0%	NS
2000	3,706	3,853	-4%	***	1,368	1,575	-13%	**
2001	3,340	3,621	-8%	***	1,063	1,475	-28%	***
2002	3,092	3,513	-12%	***	649	1,275	-49%	***
All	4,082	4,306	-5%	***	1,825	2,016	-9%	***

** and *** denote differences that are statistically different from zero at the 5% and 1% level; NS denotes statistically insignificant. All corresponds to the average for 1990-2002.