AN ANALYSIS OF U.S. CHICKEN FEET EXPORTS TO CHINA

by

XIAOSI YANG

(Under the Direction of Lewell F. Gunter)

ABSTRACT

We use excess demand and supply models to estimate US chicken feet export to mainland China and Hong Kong. Three models, the GLS, 2SLS and ARDL, are used in the analysis in order to address the issues of serial correlation, endogeneity and order of cointegration and obtain robustness of results to different estimators. We find the estimation results for the excess demand equations were generally more consistent with theoretical expectation than results for excess supply models across estimators. Mainland China's anti-dumping investigation against US poultry products has been followed by significantly reduced mainland China imports of U.S. chicken feet and increased Hong Kong imports of chicken feet.

INDEX WORDS: Excess Demand, Excess Supply, GLS, instrumental variables, 2SLS, ARDL

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DEDICATION

To my parents. It is your love and support that make all this possible.

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CHAPTER 1

INTRODUCTION

1.1 Background

The United States is the largest producer and the second-largest exporter (behind Brazil) of poultry meat in the world. Poultry meat trade has grown faster than trade in beef or pork since 1990, and now exceeds both beef and pork in volume traded. The major importers of US poultry meat are Russia, China (including Hong Kong) and Mexico, which account for over a half of US export quantity. An important contributor to increased U.S. poultry exports since 1990 is the economic growth of developing countries which has increased the demand for meat. Another principal reason for the increase is that U.S. firms export chicken parts that have a low value in the United States but a higher value elsewhere.

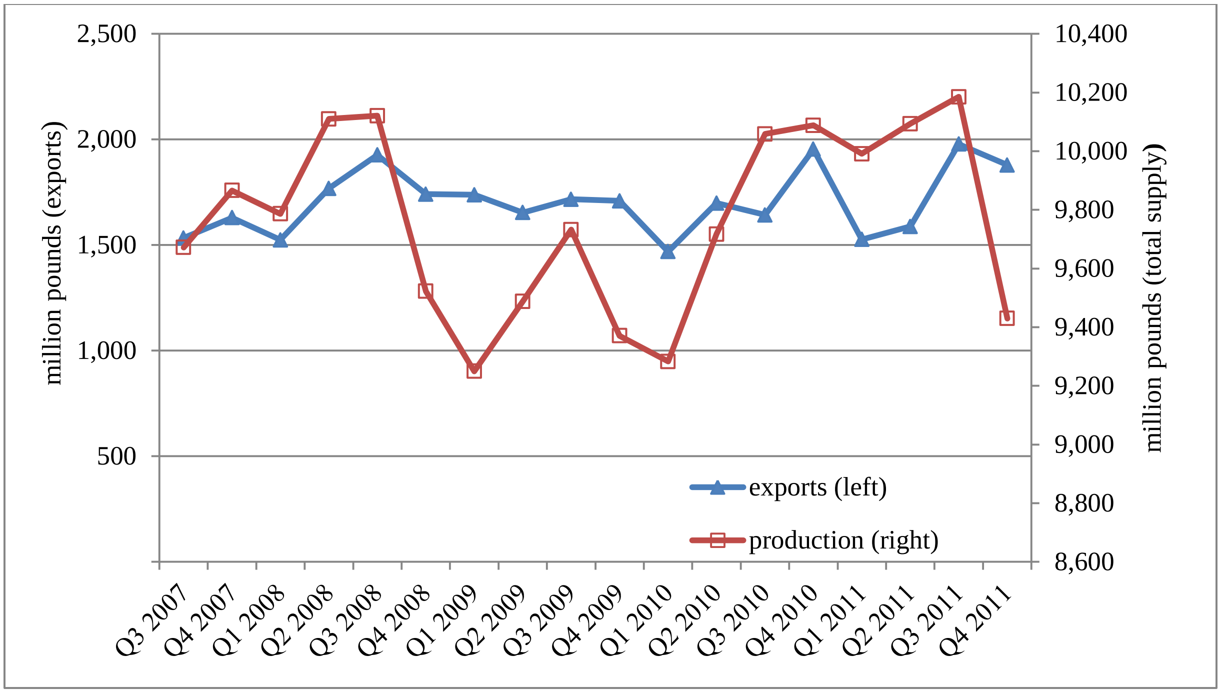

Figure 1.1 U.S. Broiler Production and Exports 2007-2011

Source: USDA "Livestock & Meat Domestic Data", 2007-2011

The exports of US broiler products are mainly frozen chicken parts. Chicken breasts, chicken wings, chicken drumsticks, chicken feet, and offal are major broiler products to export. Among all the chicken products, chicken feet are special because there is no domestic market in the United States. Chicken feet, however, are a popular snack in mainland China and Hong Kong thus accounting for an important share of US poultry exports to the China (CN)/Hong Kong (HK) market. In 2008, about half of the $677 million worth of chicken sold to mainland China was for chicken feet (Pierson, 2011). In 2011, chicken feet imports continued to dominate mainland China's total broiler imports, accounting for over two thirds of mainland China's total broiler product imports.

The high demand for imported chicken feet in mainland China is largely caused by insufficient domestic supply. The majority of the chicken feet produced in mainland China are exported to Japan or Korea for better prices. So China imports large amount of chicken feet annually to meet increasing demand. Hong Kong has very limited agricultural production. Only 57% of the live poultry consumed in Hong Kong came from local farms in 2011 (Hong Kong Fact Sheet-Agricultural and Fisheries, 2011), and most of the frozen chicken parts consumed, including chicken feet, are imported. The consumption of chicken feet in mainland China and Hong Kong has a clear seasonal trend. Chicken feet are in high demand from April to October. After the peak season, the consumption decreases until next April (USDA GAIN Report, 2006).

The two major exporters of chicken feet to the CN/HK market are the United States and Brazil. Brazil has the second largest poultry meat production in the world and is the largest exporter. It is also the major poultry meat provider for Hong Kong. In 2010, the Hong Kong market absorbed about 9% of Brazil's total chicken meat exports. However, Brazil's direct exports to mainland China accounts for only a small trade volume.

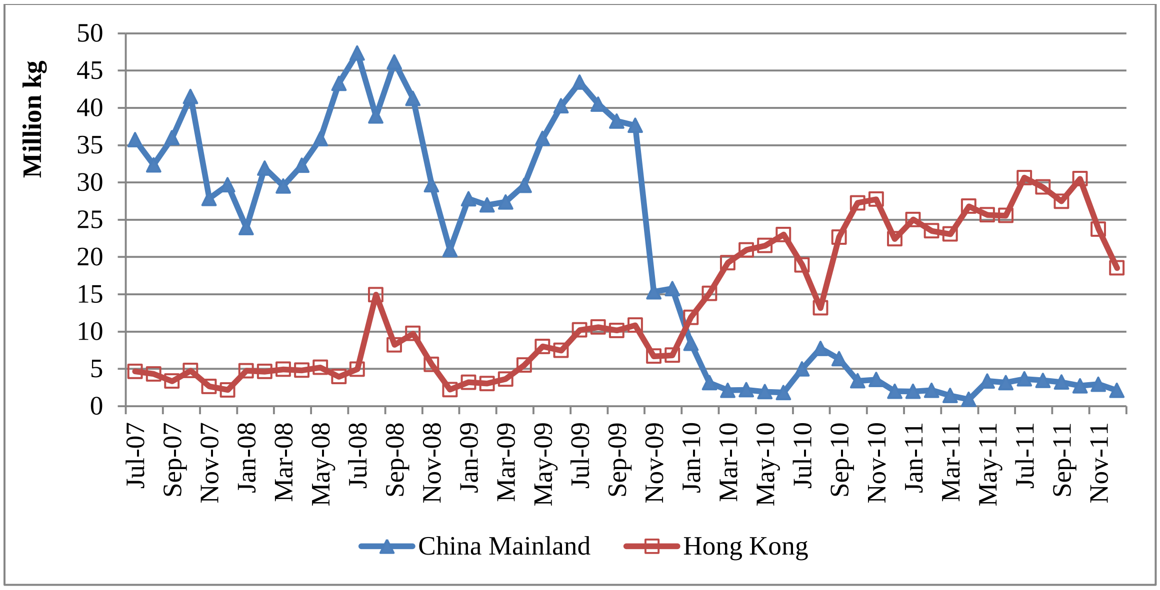

Figure 1.2 U.S. Chicken Feet Exports to Mainland China and Hong Kong

Source: United States International Trade Commission (USITC)

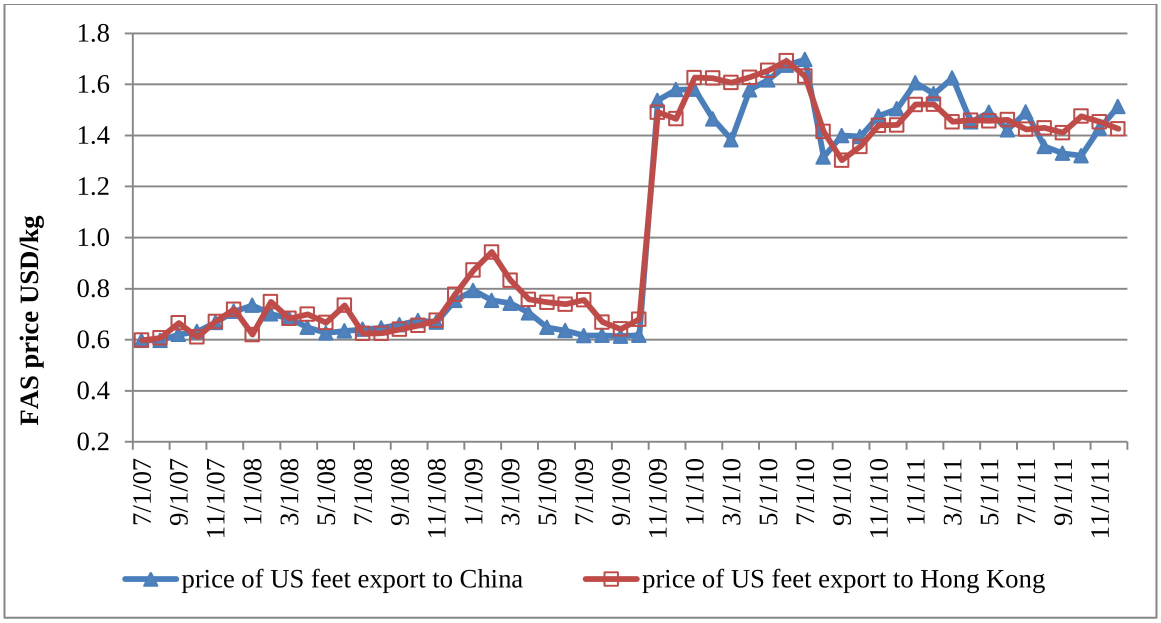

Figure 1.3 Free Alongside Ship (FAS) Price of U.S. Chicken Feet Exports to CN/HK

Source: United States International Trade Commission (USITC)

Figures 1.2 and 1.3 show the prices and quantities of U.S. exports to mainland China and Hong Kong over time. The sharp increase in the U.S. chicken feet export price is coincides with the anti-dumping investigation by China in September 2009. With tariffs, there is a separation between consumer and producer prices, normally the producer price goes down and the consumer price goes up. In this case, we don't know what the mainland China and Hong Kong consumer price for U.S. chicken feet was before and after the policy change. The price here is free alongside ship price (FAS) per unit, which is the transaction price of the merchandise at the U.S. port of exportation but excludes any loading, transportation, or insurance costs beyond the port of exportation (International Trade Administration). Thus this FAS price we used in analysis approximates the producer price but not the consumer price. It goes up while we expected it to go down for the tariff in Figure 1.3.

Also, we can see a trend in Figure 1.2 that as mainland China's import quantity decreases sharply in last quarter of 2009, Hong Kong imports of chicken feet from the United States grew. This was likely due to transshipments from Hong Kong to mainland China or the increased consumption in Hong Kong. Hong Kong is a free port which does not levy a tariff on poultry meat while mainland China levied about 10% on poultry meat before the anti-dumping duties and much more after that. Hong Kong re-exports some unknown amount of commodities to mainland China, but the amount cannot be verified. Many studies of exports to mainland China and Hong Kong use aggregate data and treat mainland China and Hong Kong as one market. This is often reasonable, but may also lose some information. The mainland China and Hong Kong markets reacted quite differently to China's anti-dumping investigation on U.S. poultry products (Figure 1.2.), thus it is interesting to investigate the two markets separately. In this paper, first, aggregated data are used to estimate US exports to CN/HK using different econometrics methods; Second, mainland China and Hong Kong are treated separately. When estimating one market, the other market's quantity or price is added into the equation so as to account for the interaction between these two markets.

1.2 Problem Statement

Chicken feet have no market value in the U.S. domestic market, but they are popular snacks in China. Although China is the third largest poultry producer in the world, there remains a huge gap between increasing demand for chicken feet and domestic production capacity. Before the United States began exports of this by-product to China, U.S. produced chicken feet went to rendering for such purposes as animal feed. The export of chicken feet to China is complementary to the U.S. poultry production and also beneficial for Chinese consumers. Previous studies mostly focus on the U.S. poultry meat exports as a whole, rather than chicken parts. Also, there is no known study using a time series model to analyze the market for chicken feet.

China's currency has appreciated significantly since 2007, and which should increase the domestic demand for chicken feet imported from the United States. When China imposed the antidumping duty on U.S. poultry products, however, that should have led to a decrease in U.S. export quantity and U.S. producer price. However, the data observed showed a significant decrease in the U.S. export quantity but an increase in export unit price. As China decreased chicken feet imports from the United States, Hong Kong imported almost doubled at very high price level. To explain these phenomena, it is necessary to investigate the interaction between the chicken feet markets of mainland China and Hong Kong.

1.3 Objectives

The objective of this paper is to investigate the two major markets for U.S. chicken feet exports, mainland China and Hong Kong, estimate the excess demand and excess supply of US chicken feet export using three different econometric methods, compare results from different methods, and assess the impact of the exchange rate and tariff.

The specific objectives for the following chapters are

- To estimate the excess demand and excess supply models in two cases: treat mainland China and Hong Kong as one market; treat them as different markets.
- Use Generalized Least Squares, the Autoregressive Distributed Lag model, and 2SLS to obtain parameter estimates and assess the short-run and long-run export demand and supply for U.S. chicken feet.
- To determine the impact of the significant appreciation of China's currency from 2007 to 2011 and assess the impact of anti-dumping duties imposed on US chicken feet exports and draw implications.
- To evaluate the connection between the mainland China market and Hong Kong market and determine how the excess demand and supply of one market will have impacts on the other market.

1.4 Organization

Chapter 2 introduces the trade policies and the exchange rate issue of mainland China on poultry meat and discusses the influences on U.S. chicken feet exports. Chapter 3 is devoted to the econometric methods used to analyze the excess demand and excess supply model and the specification of the variables and data used in the model. Chapter 4 presents estimation results from GLS, ARDL, and 2SLS, as well as, discussion of results. Chapter 5 pertains to the conclusions of the study and specifically addresses the differences in expected and actual results.

CHAPTER 2

TRADE POLICIES AND REGULATIONS

2.1 The Antidumping Issue

Poultry was one of China's top four agricultural imports from the United States during 2005–09, growing at an average annual rate of over 50 percent. The United States share of China's poultry imports rose from 53 percent to 80 percent during 2005–09, gradually edging out poultry imports from Argentina and Brazil.

In September, 2009, China initiated antidumping (AD) and countervailing duty (CVD) investigations on poultry products from the United States. Based on the findings, China imposed on these products AD and CVD duties on September 26, 2010 and August 30, 2010, respectively.

In the AD investigation, the imposed dumping duties ranged from 50.3 percent to 53.4 percent for the participating U.S. producers and an "all others" rate of 105.4 percent. In the CVD investigation, the imposed countervailing duties are between 4.0 percent and 12.5 percent for the participating U.S. producers and an "all others" rate is 30.3 percent. (Office of the US Trade Representative) These tariffs pertained to mainland China but not Hong Kong.

U.S. poultry meat exports to mainland China fell sharply in October 2009, right after China started the antidumping investigation on U.S. poultry products. China's imports of U.S. broiler meat declined by 80 percent during January–July 2010 as compared with the same period of the previous year (USDA, FAS). China's import quantity of chicken feet fell by a half in October 2009 compared to the previous month. The free alongside ship (FAS) price of chicken feet doubled after October 2009. After the sharp drop in volume, U.S. direct feet exports to China remained at a very low level.

Hong Kong imported an average of 1/5 of the quantity of the U.S. chicken feet export to China before the fourth quarter of 2009. However, after that, as the import of Mainland China declined, Hong Kong's imports from the United States increased greatly, exceeded mainland China's imports and almost doubled in 2011 compared to its previous import (Figure 2.1). If combined the import quantity of chicken feet (Figure 2.2), it seems that mainland China's sharp decrease in imported chicken feet was significantly offset by the increased Hong Kong imports from the United States. The total quantities of chicken feet CN/HK imported from the United States dropped much less than the quantity imported to mainland China only. Values of the combined exports to mainland China and Hong Kong (at FAS price) actually increased over the period (Figure 2.2).

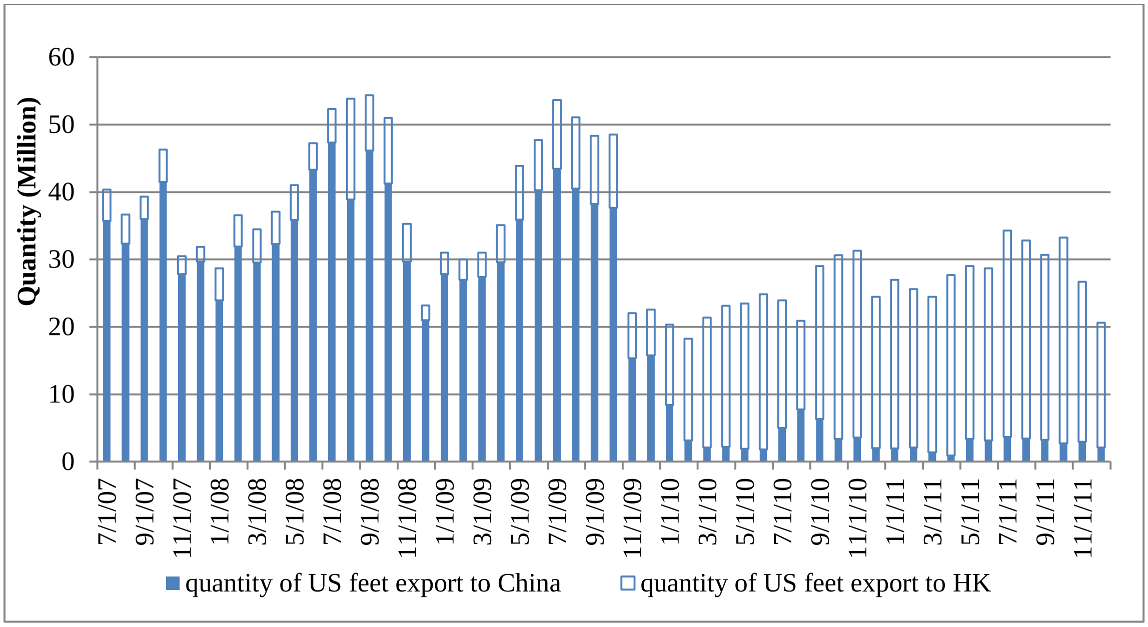

Figure 2.1 Quantity of U.S. Chicken Feet Exports to mainland China and Hong Kong

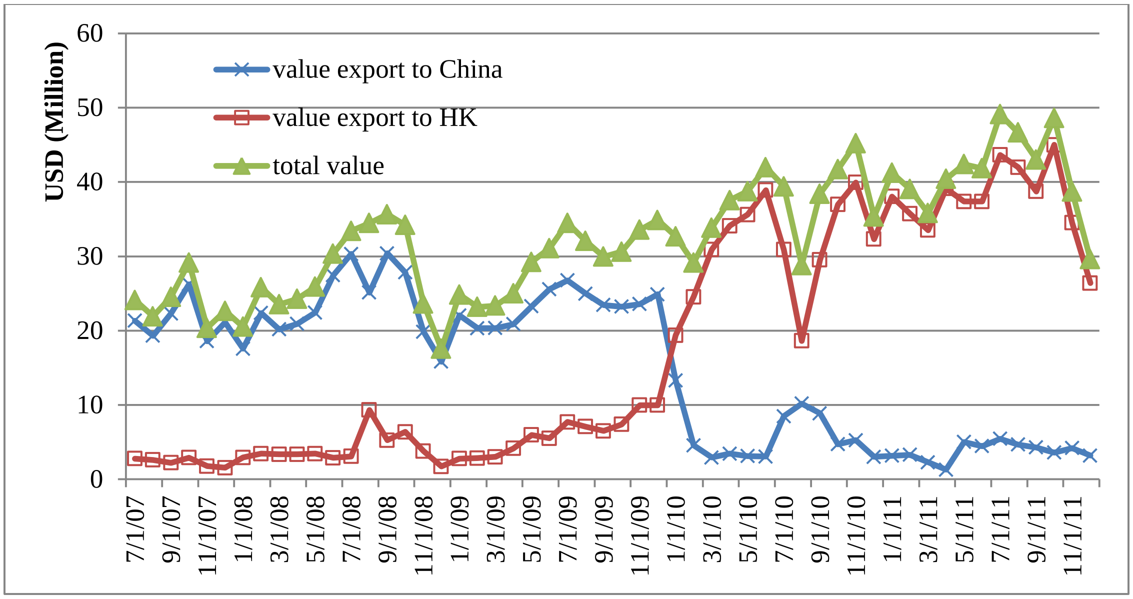

Figure 2.2 Values of U.S. Chicken Feet Exports to Mainland China and Hong Kong

2.2 The Exchange Rate Issue

The exchange rate is another important factor in international trade. China had a fixed exchange rate, pegged to the U.S. dollars for decades, the CNY/USD ratio was stable at 8.2 from 1997 to 2005 (Figure 2.3). China began to use the managed floating exchange rate system in July 2005, which allowed the Yuan to appreciate gradually relative to the U.S. dollars. To the extent that the exchange rate float is passing through to Chinese consumers, the significant appreciation of CNY to USD makes US chicken products relatively cheaper over time and should increase the demand for imported chicken feet. However this effect is not observed from the data. The actual data show a reverse trend with lower quantities of U.S. chicken feet exports to China after September 2009. One possible reason may be that the effect of exchange rate was offset by the antidumping duty imposed on U.S. poultry products during the same time period. Thus, both China's exchange rate and the antidumping duty should be included in the analysis.

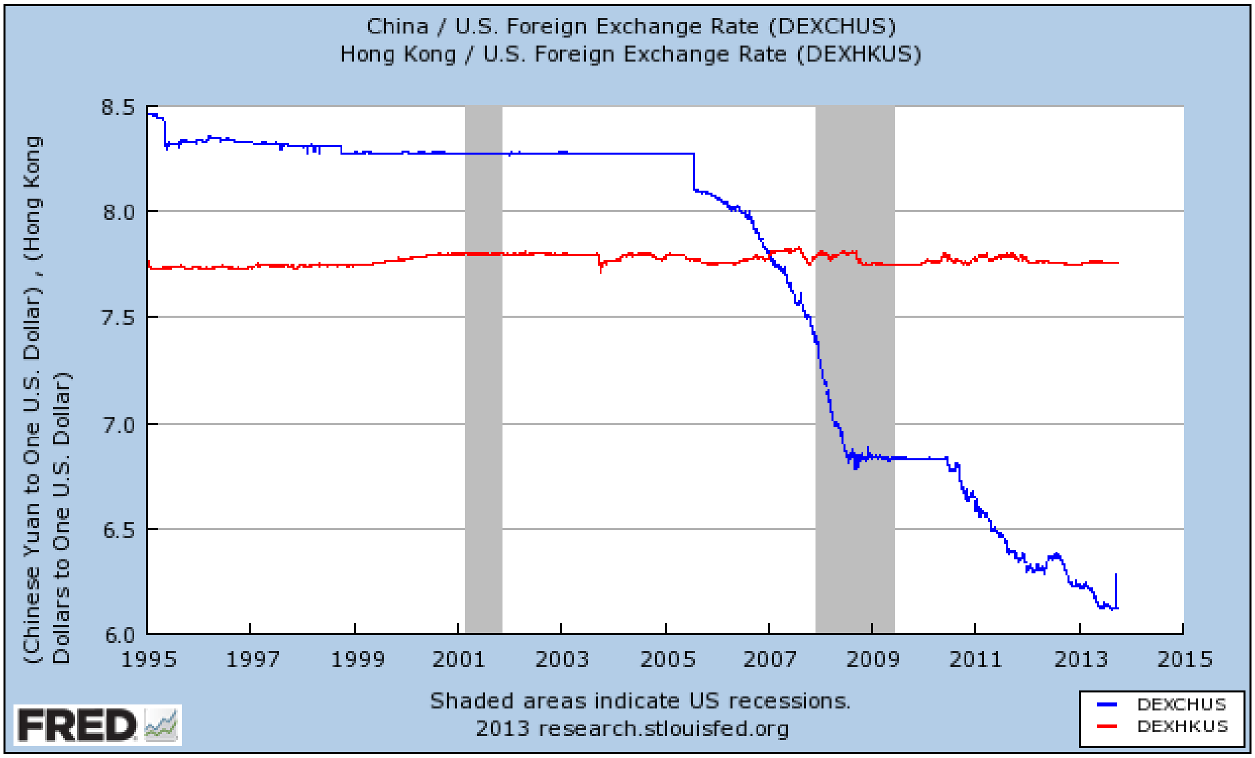

Figure 2.3 Exchange Rates of CNY/USD and HKD/USD, 1995-2012.

Source: Federal Reserve Economic Data

Hong Kong has a pegged exchange rate system which keeps the exchange rate between the HK dollars and the U.S. dollars at a certain level. The HKD/USD rate has a lower limit of 7.8. If the rate is lower than 7.8, the banks authorized by Hong Kong's central bank (Hong Kong Monetary Authority (HKMA)) converts USD for HKD through HKMA to increase the supply of HKD. Therefore, Hong Kong's exchange rate has very little fluctuation and it is not necessary to include Hong Kong's exchange rate as an explanatory variable in the model.

2.3 Trade and Transshipment between Hong Kong and Mainland China

The port of Hong Kong is one of the busiest ports in the world, and as a free port, it is also an important transshipment site for mainland China. The transshipment cargo movements between Hong Kong and the mainland China accounted for the largest share (40.3%) of Hong Kong's port transshipment cargo in 2011, followed by the U.S.A. (6.6%), Taiwan (5.0%), Japan (5.0%) and Vietnam (4.8%). If analyzed by country of loading/discharge, the largest share of transshipment cargo movements between Hong Kong and the Mainland was related to the United States (9.9%) in 2011. (Census and Statistics Department of Hong Kong, 2012) A large amount of broiler meat, including chicken feet is shipped to Hong Kong and reshipped to mainland China. Unfortunate broiler transshipment data are not disaggregated by parts, and are available only on an annual (not monthly) basis. Also, the transshipments between mainland China and Hong Kong are not verifiable from any source outside of the Chinese government.

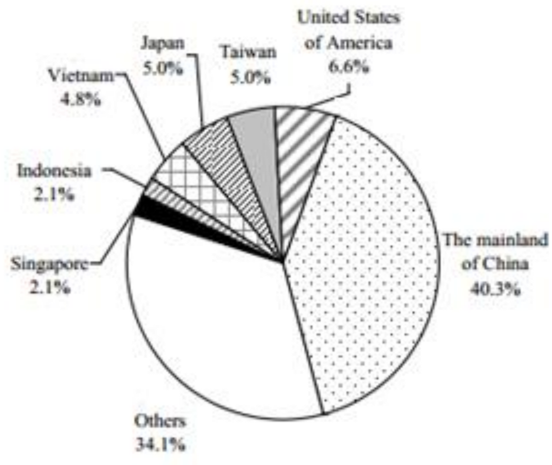

Figure 2.4 Port of Hong Kong Transshipment Cargo by Country, 2011

Source: Hong Kong Monthly Digest of Statistics, May 2012, Census and Statistics Department of Hong Kong

CHAPTER 3

MODELING U.S. CHICKEN FEET EXPORT TO MAINLAND CHINA AND HONG KONG

The theoretical model used in this paper is an excess demand and excess supply model based on two previous studies (Zhang, 2002; Li, et al. 2011), which examined different U.S. chicken parts exports to the aggregated CN/HK market. The chicken parts studied in their papers included chicken wings, legs and feet, but the results for chicken feet using OLS, three stage least squares (3SLS) and generalized method of moments (GMM) was not satisfactory. They tried different functional forms using level data, but did not explore the time series properties of chicken feet exports. Chicken feet data are serially correlated, however, and there may also be an endogeneneity problem between prices and quantities in ED-ES equations, as they are simultaneously determined. To address these problems we used three alternative estimation methods to explore U.S. chicken feet exports.

To address autocorrelation in the error term of the time series data, the Prais-Winsten procedure of Generalized Least Squares (GLS) is used to obtain the correct parameter estimates.

The second method used is the Autoregressive Distributed Lag (ARDL) model. The ARDL model is a more generalized way to analyze time series data and it does not require the variables to cointegrate at the same level. As long as the variables cointegrate at an order less or equal than 1, this model will work.

The third method focused on addressing the endogeneity problem. We used a two stage least square (2SLS) model to estimate the excess demand and excess supply equations.

3.1 Excess Demand-Excess Supply Model Description

The basic model to estimate chicken feet trade between the United States and mainland China/Hong Kong is an excess demand and excess supply model. In the excess supply model, the supply quantity is a function of export price and the supply and demand conditions of the export country and the rest of the world. To be specific, the excess supply of U.S. chicken feet to mainland China/Hong Kong is modeled as a function of the export price to CN/HK, the quantity of U.S. broilers produced, and export price to the rest of the world. This specification assumes that the quantity of chicken feet available for export is in fixed proportion to U.S. broiler production and exports are allocated to available markets based on prices in those markets.

The excess demand quantity is assumed to be a function of export price, supply and demand conditions of import countries, consumers' budget constraint and other factors that may influence demand. Specifically in our empirical model, the excess demand is determined by the U.S. export price to CN/HK, the domestic price of related consumer goods in CN/HK, and income in CN/HK (captured by GDP). Note that we do not have knowledge of Chinese/HK consumer prices of U.S. feet, but those prices should be related to the U.S. export price and the price of related consumer goods in CN/HK, which are included in the model.

Besides the basic variable specification in the model, there are other factors that affect chicken feet trade. For the excess supply equation, because chicken feet are unpopular in the United States, there is no U.S. domestic price of feet in the model. For the excess demand model, Brazil is the other major poultry meat exporter to CN/HK and a big competitor for U.S. poultry meat exports. Therefore, the export price of Brazil should have an impact on the excess demand for U.S. feet to consumers in CN/HK. Brazil's exports to China are mainly whole birds and the frozen chicken parts. However, the separate data for frozen chicken feet are not available. So we use the unit price of fresh or frozen cuts of Gallus domesticus as an indicator of Brazil's export price to CN/HK. Since this price is not specifically for feet, it should represent the general availability of Brazilian chicken exports to the Chinese market and reduce endogeneity problems associated with the variable in the excess demand model.

The exchange rate for China and the United States affect the trade of chicken feet between the two countries. As international trade theory indicates, the appreciation of currency in the importing country will increase the demand for chicken feet. So the excess demand model includes the exchange rate as one of the independent variables.

Consumption in CN/HK has a clear seasonal pattern, thus a seasonal dummy variable is included in the model, 1 for months from April to October each year, 0 otherwise. Another dummy variable in the model indicates the sudden change in China's tariff policy with the United States. Although the actual tariff was imposed in 2010, the sudden drop in China's chicken feet imports started in October 2009 when China initiated antidumping and countervailing duty investigations on chicken products imported from the United States. Therefore, the structural break dummy variable has a value of 0 before October 2009 and 1 thereafter.

3.1.1 The General Excess Demand and Excess Supply Model

The excess demand for chicken feet is a function of own price, price of local whole broilers, price of chicken imports from Brazil, GDP in mainland China or HK, exchange rate (Yuan per Dollar) and anti-dumping policy and seasonal dummy variables. Here we estimated separate markets of mainland China and Hong Kong and also estimated the aggregate market.

The excess demand model can be written as:

$$Q^{d}{}_{us\_i,t} = f(P_{us\_i,t}, P_{bro\_i,t}, P_{bz\_i,t}, GDP_{i,t}, ER_{cn,t}, D_{break,t}, D_{seasonal,t}) \qquad (1),$$

where

i=mainland China, Hong Kong, or the aggregate market

$P_{us\_i,t}$= Unit FAS price of U.S. frozen chicken feet exports to place i in time t (million kg)

$P_{bro\_i,t}$= Average monthly price of broilers in place i at time t

$P_{bz\_i,t}$= Unit price of Brazilian frozen fowl cut exports to place i

$GDP_{i,t}$= monthly GDP of place i

$ER_{cn,t}$= Monthly average exchange rate CNY/USD

$D_{break,t}$= Dummy variable for the structural tariff break in the data in October 2009, 1 after October 2009, 0 otherwise

$D_{seasonal,t}$= Seasonal Dummy for feet consumption from April to October each year, 1 from April to October, 0 otherwise

The excess supply for chicken feet is a function of U.S. broiler production, own price, price of feet exports to the rest of the world, and anti-dumping policy and seasonal dummy. It can be written as:

$$Q^{s}{}_{us\_i,t} = f(Q_{broiler\_us,t}, P_{us\_i,t}, P_{us\_row,t}, D_{break,t}) \qquad (2),$$

where

i=mainland China, Hong Kong, or the aggregate market

$Q_{broiler\_us,t}$= Total number of U.S. broilers slaughtered (million head)

$Q_{us\_i,t}$ =Quantity of U.S. frozen chicken feet exports to place i in time t

$P_{us\_i,t}$= Unit FAS price of U.S. frozen chicken feet exports to place i in time t

$P_{us\_row,t}$= Unit FAS price of U.S. frozen chicken feet exports to the rest of world in time t

$D_{break,t}$= Dummy variable for the structural tariff break in the data in October 2009, 1 after October 2009, 0 otherwise

The previous study by Zhang (2001) examined exports of several frozen chicken cuts to China/Hong Kong in an excess demand and excess supply framework using three stage least squares (3SLS) and multiple functional forms. Estimates for all parts were in levels and time-series properties and methods were not employed. These models performed reasonably well for some chicken cuts but the poorest results were for exports of feet with respect to explanatory power and coefficient significance.

In this study we pay greater attention to econometric problems associated with estimating ED and ES for feet and use multiple estimators to analyze the market. The purpose of this approach is to use estimators that focus on different econometric problems associated with the analysis and compare findings across estimators to check the robustness of the results for the estimators used. We also wish to determine if the poor results for the 3SLS estimation for feet in Zhang’s study were due to the simplicity of the 3SLS estimator.

3.2 Prais-Winsten Method of GLS

For the first estimator, we tested level equations for excess demand and excess supply for auto correlation and estimated a Prais-Winsten GLS version of the model. This approach corrects for a simple time series property of the error terms.

The Prais-Winsten regression is a generalized least square (GLS) estimator which correct for serial correlation. This estimator is an improvement on the Cochrane-Orcutt (1949) method. The first observation is preserved compared to the Cochrane-Orcutt method, which is an advantage to estimate samples that are not very large. Since there are 54 observations in the data, we choose this method rather than the Cochrane-Orcutt method.

The linear regression model to be estimated can be written as

$$y_t = X'\beta + u_t \quad (3),$$

and

$$u_t = \rho u_{t-1} + \varepsilon_t \quad (4),$$

where y is a vector of dependent variables, X is the matrix of explanatory variables, u is the error term which should satisfy the equation (4).

To use the P-W method, the Durbin-Watson test is conducted to confirm the existence of serial correlation. (Gujarati 1995) The formula to calculate the test statistics is

$$DW = \frac{\sum_{t=2}^{T}(\hat{u}_t - u_{t-1})^2}{\sum_{t=1}^{T}\hat{u}_t^2} \quad (5).$$

A DW test value around 2 indicates there is no first order serial correlation; a value below 2 indicates there is positive serial correlation and a value above 2 but less than 4 means there is negative serial correlation. The test results show that all of the models have DW values less than 2 which verifiy the existence of positive serial correlation. The mainland China and Hong Kong's excess supply equations have DW values less than one and other equations range from 1.069 to 1.557. Thus, it is necessary to use Prais-Winsten method to correct the serial correlation. Equation (1) and (2) are estimated using GLS.

3.3 ARDL Model and Empirical Procedure

3.3.1 ARDL model

An Autoregressive Distributed Lag model (ARDL) was the second estimator we used. This estimator is a time series method to address the cointegration problem usually inherent in time series data. ARDL has some econometric advantages in comparison to other time series models:

1) The ARDL method can reduce the problem of endogeneity.
2) The bounds test for cointegration used by ARDL can be applied irrespectively the order of integration of the variable. The variables may be either integrated at I(1) or I(0). The short-run and long-run coefficients of the model are estimated simultaneously.

The Augmented Dicky-Fuller test results show that the data are not cointegrated at the same level. Some of the variables are stationary in levels while others are stationary only after first-order differentiation. Also, the exchange rate, one of the main explanatory variables, has a clear time trend. After regressing the exchange rate on time, the residual becomes stationary and can be used in analysis. Given the diversity in the data, the second advantage of ARDL model makes it suitable for the Excess Demand and Excess Supply model.

Following Pesaran et al. (2001), the ARDL approach to cointegration is given by

$$y_t = c + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{j=1}^{n} \sum_{i=0}^{q} \beta_{ji} x_{j,t-i} + \varepsilon_t \qquad (6),$$

where y_t is the excess demand or excess supply, y_{t-i} is the i^{th} lag of the dependent variable, $x_{j,t-i}$ denotes all the independent variables and the proper number of lags. c is the intercept of the model and ε_t is the error term. p and q are lag orders to be determined in the model estimation. Here, α_i and β_{ji} are parameter coefficients to be estimated.

The error correction representation of the ARDL model is given by

$$\Delta y_t = c + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \sum_{j=1}^{n} \sum_{i=0}^{q} \gamma_{ji} \Delta x_{j,t-i} + \varphi y_{t-1} + \sum_{j=1}^{n} \delta_j x_{j,t-1} + u_t \qquad (7).$$

Equation (6) represents the long-run relationship, while equation (7) indicates the short-run relationships between excess supply/demand and corresponding explanatory variables, where Δ indicates the change in value of y and x from the period t-1 to period t.

The null hypothesis of the ARDL error-correction model is H_0: $\varphi = 0$ and $\delta_j = 0$, which means the long-run relationship does not exist. The alternative hypothesis is H_a: $\varphi \neq 0$ and $\delta_j \neq 0$. The bounds test is used to determine whether the null hypothesis should be rejected or not.

The calculated F-statistic is compared with the critical value tabulated by Pesaran (1997) and Pesaran et al. (2001). There are an upper critical value and a lower critical value. These two critical values provide bounds for all possibilities of the regressors into purely I(0), I(1) or mutually cointegrated. The null hypothesis can be rejected if the computed F-statistic is above the upper critical value, and which means the variables are cointegrated. Conversely, the null hypothesis cannot be rejected if the F-statistic is below the lower critical value. If the F-statistic falls between the upper bound and lower bound, the inference is inconclusive.

The lag lengths, p and q, are chosen by minimizing Akaike Information Criterion (AIC). The F-statistic is computed after the proper number of lags is determined. Bayesian Information Criterion (BIC) usually selects fewer lags than AIC, but it doesn’t mean it’s a better way than AIC. We chose the number of lags based on AIC.

The Augmented Dickey-Fuller test is conducted to make sure order of integration for all of the variables does not exceed one. We find that all the variables are integrated at order zero or at order one, except the exchange rate between the United States and China. Visual inspection of the exchange rate over time also suggests that it is non-stationary. The exchange rate has a downward trend. To eliminate the time trend, the exchange rate is differenced and then tested again. After differencing, the exchange rate data is integrated at the order one. Thus, all of the data in the analysis are integrated at level or first difference, and the ARDL prerequisite is satisfied.

3.3.2 Empirical model specification with cross quantity between two markets

As mentioned before, Hong Kong is an important transshipment port for mainland China. Thus, mainland China's excess demand and the U.S. excess supply to mainland China are also affected by the quantity imported by Hong Kong, and similarly Hong Kong's demand and imports from the United States. may also related to mainland China's demand. Since the monthly data of poultry re-export to mainland China from Hong Kong is unknown, for some specifications we include the quantity of poultry Hong Kong imported from the United States in China's excess demand and supply equations in the ARDL models. Similarly, Hong Kong's excess demand and supply equations will also include quantity of poultry meat that mainland China imported directly from the United States in some specifications.

The equation of excess demand with cross quantity is

$$Q^{d}{}_{us\_i,t} = f\,(P_{us\_i,t}, P_{bro\_i,t}, P_{bz\_i,t}, GDP_{i,t}, ER_{cn,t}, Q_{us\_j,t}, D_{break,t}, D_{seasonal,t}) \qquad (8),$$

and the equation for excess supply with cross quantity is

$$Q^{s}{}_{us\_i,t} = f\,(Q_{broiler\_us,t}, P_{us\_i,t}, P_{us\_row,t}, Q_{us\_j,t}, D_{break,t}) \qquad (9),$$

where $i \neq j$, indicating the two different markets.

We also estimated this ED-ES model with lagged import quantity of the other market, i.e., $Q_{us\_j,t-1}$ is included in excess demand and supply equations of market i. This is to reduce the endogeneity problem by including contemporaneous exports to the alternate market.

In total, four pairs of ARDL models are estimated:

a) Aggregated model using combined data of CN/HK,

b) Separate ED-ES models for mainland China and Hong Kong,

c) Separate ED-ES models for mainland China and Hong Kong with contemporaneous import quantity variables for HK imports in China equations and China quantity in HK equations, and

d) Separate ED-ES model for mainland China and Hong Kong lagged import quantity variables for HK imports in mainland China equations and mainland China import quantity in the HK equations.

The statistical software we used to estimate the ARDL model is Microfit 5.0 which can automatically select the optimal number of lags. Given the number of observations, we set a maximum of three lags for each explanatory variable. Theoretically we can choose any maximum number of lags. In fact with monthly data, some studies have involved a choice of 12 lags. Although more lags may yield better estimation results, it may be difficult to explain the economic implications.

3.4 Method of Two Stage Least Squares (2SLS)

The third estimator we used was a 2SLS model, a simultaneous equation approach. The two previous estimators used single equation models and focused on time series characteristics of the data. One drawback of those models is that, as single equation models, they treat all right hand side variables as exogenous. By including lags of all model variables in the analysis, the ARDL approach partially addresses endogeneity problems, but we also wanted to use an estimator that gives greater emphasis to the problem of own-price endogeneity.

In this excess demand and excess supply model, the price and quantity can be jointly determined by exogenous variables such as domestic supply and demand. Second, reverse causality may exist in demand and supply models. Although US export quantity could be expressed as a function of several prices, a shock to demand or supply can also cause price to change. This likely happened when China imposed an anti-dumping tariff on U.S. poultry products. To account for the endogeneity problem, we use all of the exogenous variables as instruments for price in the excess demand and excess supply equations. Equations (1) and (2) are estimated using 2SLS. Because many variables in the data are non-stationary in level, we first differenced them to make them stationary. However, the quantity of U.S. export to the aggregate market, which is the dependent variable in equation (1), is stationary in level but non-stationary in first difference. So when estimating the aggregate market, the level dependent variable is used to keep all variables stationary. When estimating the other two markets, the first differenced dependent variable is used.

3.5 Data

Monthly data from July 2007 to December 2011 are used in the study. U.S. export data of chicken feet were obtained from the United States International Trade Commission (USITC), which includes monthly data for U.S. chicken feet quantities and unit prices for exports to mainland China, Hong Kong, and rest of the world respectively. We use number of chickens slaughtered as an indicator of U.S. chicken production. The number of chickens slaughtered was obtained from USDA ERS Livestock & Meat Domestic Data. Exchange rate between the Chinese Yuan and the U.S. dollar was obtained from Federal Reserve data base.

GDP data for mainland China were obtained from the National Bureau of Statistics of China. The quarterly data is from the third quarter of 2007 to the fourth quarter of 2011. The linear-match last method is used to convert the quarterly GDP data to monthly data. This way inserts the low frequency observation values into the last period of the high frequency data, and then performs linear interpolation on the missing values. China's domestic broiler prices were obtained from USDA GAIN China Poultry and Products Semi-annual Reports.

Hong Kong's monthly GDP and local broiler prices were obtained from the Hong Kong Census and Statistics Department. Brazilian poultry export prices to mainland China and Hong Kong were obtained from the System Information Analysis of Foreign Trade via the Internet. Data were obtained from the HS 6 subheading from 020711 to 020714, including whole chicken and chicken part exports to Mainland China and Hong Kong. All variables except dummies are in natural logarithm form for the analysis.

CHAPTER 4

ESTIMATION RESULTS

4.1 Results using GLS Prais-Winsten Method

In general, the GLS Prais-Winsten method has more explanatory power for excess demand rather than excess supply.

In the excess demand equation for the aggregate market, the own price, exchange rate, and seasonal dummy coefficients are significant different from zero with expected signs. But on the excess supply side, the only significant coefficient is own price in mainland China market, but has a negative sign though theory suggests a positive sign. The ED-ES model does not fit mainland China well for either equation. The excess demand equation for mainland China failed the F test, and has a very low adjusted R square value (0.07). The excess supply results for mainland China are similar. There are no significant coefficients for either excess demand or excess supply in the mainland China model.

The Hong Kong results are much better, especially on the excess demand side. Coefficients for own price, price of local broilers, price of Brazilian export to Hong Kong and two dummy variables are all significant at 0.01 with expected signs. Hong Kong's local broilers' price and the Brazil's chicken export price to Hong Kong positively affect the U.S exports to Hong Kong, indicating they are substitutes for U.S. chicken feet. The tariff dummy variable has positive effect on U.S. exports to HK, which matches the graph and is likely explained by transshipments between mainland China and Hong Kong. The adjusted R square is about 0.59 and the F statistics is significant at the 0.1 level which means the model has fairly good explanatory power for the HK market. The excess supply equation is not satisfactory. The adjusted R square is very small (less than 0.1) and only the own price coefficient is significant.

4.2 ARDL Long Run and Short Run Results

Using Microfit 5.0, the best models are obtained by AIC criteria and the selected model is listed. Most of the results passed the bounds test, which indicates the long-run relationships from the excess supply side and excess demand side both hold. The only ARDL long-run equation that doesn't hold is Hong Kong's excess supply with Mainland China's quantity as interaction term. Since the results show that the long-run relationships all exist in our three pairs of models, we further obtain the specific parameter estimates of individual variables and the error correction models (ECM).

4.2.1 The Aggregate Market

Both the excess demand and excess supply models of the aggregate market passed the bounds test, which means there exists a long-run relationship between the dependent variable, US export quantity to CN/HK aggregate market, and a set of independent variables. The adjusted R square is 0.702 for excess demand side and 0.529 for excess supply. In excess demand model, three variables are significant. The own price is negative, aggregate GDP has a positive sign and the seasonal dummy also holds a positive sign. But in excess supply model, the t-statistics are less satisfactory because only the own price is significant. In short run, the export quantity in both excess demand and supply side relies on the export quantity of the previous time period. And those significant in long run also affect the short run supply and demand.

4.2.2 Mainland China Market

China's excess demand and excess supply equations with all three specifications pass the bounds test and all ECMs are significant, with values between -1 and 0. However the adjusted R squares are not very large (from 0.370 to 0.471). Generally the demand side has better parameter estimates than the supply side and short-run parameter estimates are more significant than long-run. The own price and exchange rate are significant across three specifications in long-run excess demand side. Coefficients of both variables have significant negative signs as theory suggests. The quantity of chicken feet US export to Hong Kong and its one time lag are significant negative at 0.05 and 0.1 level respectively, implying the mainland China and Hong Kong are substitute markets for US chicken feet export.

The structural break dummy variable actually doesn't have much influence on US export quantity to mainland China, compared to the graph. But it is significant in Hong Kong's excess demand models.

4.2.3 Hong Kong Market

All the Hong Kong's excess demand and excess supply models passed the bounds test except for the excess supply with the cross quantity of US export to mainland China and all the ECMs are significant. The adjusted R squares in excess demand models are much larger than in excess supply models. All the three specifications of excess demand model have adjusted R square greater than 0.7, indicating a good fit of the model, compared to the 0.3 to 0.4 of excess supply models.

Most of the parameter estimates in Hong Kong's excess demand side without the cross quantity variable are significant and have the expected signs. Hong Kong's local broiler price has a positive sign as a substitute for imported chicken feet. Brazil's export price to Hong Kong also holds a positive sign since it's the biggest competitor to US among all poultry exporters. The decline in Brazil's price will attract more buyers from HK and take some shares from US.

The structural break variable in all the specifications is significantly positive. When China imposed antidumping charges, HK demands more chicken feet and US also export more to HK. It is possible that the abundant chicken feet will be transshipped to mainland China, and it also provide an explanation for insignificance of the structural break variable in mainland China's models. Here although the two markets have independent trade policies, mainland China's trade policy could still affect HK market because of the close economic connection.

The two excess demand models with cross quantity of mainland China don't generate so many significant variables as the base model does. The quantity of US export to mainland China has significant negative effect on the dependent variable, which is consistent with the result in mainland China models. In the short run, most variables are significant but they take effect through different time lags.

4.3 Results from 2SLS Method

In general, the 2SLS method doesn't generate satisfactory result. In excess demand side, although all three markets have significant Chi-square values, the R^2 is very small, ranging from 0 to 0.264. Such a small R^2 may indicate that the 2SLS model doesn't suitable for the analysis. Also, there are very few significant coefficients in all three cases. For aggregate market, changes in exchange rate and GDP are significant. The change in GDP has a positive effect on the change in U.S. chicken feet export to the aggregate market and the change in exchange rate has a large negative impact. For mainland China market, nothing is significant and the R^2 is zero. For Hong Kong market, the change in Brazil exports to Hong Kong and the seasonal dummy variable are significant and positively affect the U.S. chicken feet export to Hong Kong as we expected. But still, the R^2 is only 0.116.

In excess supply side, the R^2 is even smaller and no coefficients are significant.

4.4 Summary of Effects Across Estimators

4.4.1 Overall Excess Demand Models

The excess demand side has much significant results than excess supply side. There are more significant coefficients with expected signs in excess demand side. However, not all of them are consistent over different estimating methods.

The exchange rate of CNY to USD is included in all the excess demand models and is one of the major factors in demand side. In aggregate market, the exchange rate is significantly negative using GLS and 2SLS. In mainland China market, it's only significant under ARDL estimator. Exchange rate is significantly negative over all three ARDL specifications of Mainland China equations in the long run, but in short run only significant in the excess demand with the lag of cross variable (quantity US export to HK). This indicates that as CNY appreciates, Chinese consumers will demand more chicken feet from US over time, but the market need time to react to the change in exchange rate and the quantity change caused by change in exchange rate is not contemporaneous. In Hong Kong market, the mainland China's exchange has no significant effect on demand side using GLS, 2SLS and long-run ARDL. But it becomes significant positive in the two short-run ARDL specifications with mainland China's cross quantity.

Turning to the effect of China's anti-dumping investigation towards US poultry exports, the ARDL result shows the structure break dummy in October 2009 is highly significant in Hong Kong's excess demand of both short and long run, but not in mainland China's models. This significant positive sign indicates that Hong Kong's excess demand for US chicken feet increased after China started the anti-dumping investigation. This could be due to the close connection between the two markets. When mainland China started levying anti-dumping tariff, US would export less to mainland China and export more to Hong Kong, because Hong Kong has its own tariff system. Importers from Mainland China would also buy more chicken feet from Hong Kong and reship to mainland China. Thus, when using data from aggregate market and mainland China, the coefficient of the dummy variable is not significantly different from zero, but in the separate Hong Kong market, it's highly significant.

However, the 2SLS and GLS results didn't verify this, because the tariff dummy is not significant in any of the three markets using 2SLS and only significant in Hong Kong's equation using GLS. The anti-dumping investigation has positive influence on Hong Kong's excess demand over time. Compared with ARDL results, the positive effect of tariff dummy variable in Hong Kong's excess demand side is consistent over ARDL and GLS estimators.

The cross quantity of the other market is only included in ARDL model, not in GLS or 2SLS for the consideration of multicolinearity. The impact of the other market is significant in excess demand side of the mainland China's model with US export quantity to HK and the lag of US export to HK. It has negative signs in long run and short run, indicating the substitute effect of excess demand in mainland China and Hong Kong. If mainland China has a lower import demand for chicken feet, it would be compensated by Hong Kong's high import. Also, the Hong Kong's excess demand is negatively affected by US export quantity to mainland China of the same time period in the long run.

Price of Brazil chicken parts exports to Hong Kong market have consistent significant positive sign over all three methods, which indicates Brazil chicken parts are substitutes to US chicken feet.

The ARDL estimation of the coefficient for local broiler price in mainland China is significant under all three specifications in both short-run and long-run but carries a wrong sign.

Hong Kong's local broiler price has a highly significant positive effect on Hong Kong's excess demand using GLS and ARDL base model, which means local broiler in Hong Kong is also a substitute for US chicken feet.

The aggregate market and mainland China market didn't show a consistent seasonal consumption pattern over the three methods. However, the seasonal dummy variable is highly significant in Hong Kong's excess demand. This means in peak seasons of chicken feet consumption, Hong Kong consumers will demand more US chicken feet.

4.4.2 Overall of excess supply models

The excess supply models in general have worse results than excess demand side. Using GLS method, the only significant variable in all three markets is the own export price. The R square of excess supply of the aggregate market is 0.484, but in mainland China and Hong Kong markets, the R square is only around 0.1. Using 2SLS methods, none of the independent variables are significant.

In excess supply equations using ARDL method, short-run effect is greater than long-run effect. In error correction model, U.S. broiler production has positive influence on its chicken feet export to the aggregate market, as expected. The own export price is negative, which is the opposite sign according to theory. In long run excess supply to the mainland China market, own export price is significant over all three specifications, and in the model with contemporaneous import quantity of Hong Kong, the price U.S. export to the rest of the world has a significant negative sign, which verifies that if the prices of the other markets increase, U.S. will instead decrease the export to mainland China and export more to those markets. In short-run excess supply to mainland China market, only the U.S. production is significant in the base model. In the model with contemporaneous Hong Kong's imports, the U.S. production, U.S. export to the rest of the world and own export price are all significant with the expected signs. In the model with lagged Hong Kong's import, the US production and own export price are significant.

In all the three specifications, the cross quantity variable is not significant, thus Hong Kong's import doesn't have too much influence on U.S. chicken feet export to mainland China. In excess supply model to the Hong Kong's market using ARDL, the results are still not satisfactory for both long-run and short-run. The long-run excess supply with contemporaneous cross quantity failed to pass the bounds test. The own export price in base model is significant but with the wrong sign.

However, the tariff dummy variable is highly significant in the long-run, which shows a positive effect on U.S. chicken feet export to Hong Kong. Even in the short-run, the tariff dummy variable is still significantly positive. So, as mainland China imposed tariff on U.S. poultry products, U.S. actually exported more to Hong Kong market.

In excess supply side, we didn't get consistent result over the three methods and this suggests the excess supply is more complicated than the model assumes.

CHAPTER 5

CONCLUSION

In this thesis, we use GLS, ARDL, and 2SLS to investigate the demand and supply of US chicken feet exports to mainland China and Hong Kong. The endogeneity, serial correlation and cointegration problems are addressed using the three methods. The short-run and long-run relationships between U.S. exported chicken feet and explanatory variables of an excess demand and excess supply model are estimated. The results show that all three methods work better for excess demand than excess supply.

For specific parameters, appreciation of the Chinese currency was found to positively cause the demand for US chicken feet to increase in the aggregate and mainland China market. However, this does not hold across all the three estimators. In the mainland China market, the Yuan appreciation raises consumer demand for US chicken feet in the long-run, but in short run the effect is not that much.

The sudden anti-dumping tariff actually did not influence US chicken feet demand for mainland China under any of the three methods which is quite different from what might seem apparent from Figure 2.1 and 2.2. However, the anti-dumping tariff affected U.S. chicken feet exports to Hong Kong. After China's anti-dumping investigation, quantity of US chicken feet export to Hong Kong increased significantly in both the long and short run and in terms of excess demand and excess supply. Essentially, the tariff of mainland China triggered increased chicken feet trade between Hong Kong and United States. This interesting phenomenon is likely due to transshipments via Hong Kong to mainland China to evade the tariff imposed by mainland China.

The connection between the Hong Kong market and mainland China market are also confirmed by the ARDL model. The quantity of chicken feet imported by Hong Kong has a negative impact in mainland China's demand models, in both the short run and long run. In reverse, the quantity of mainland China imports from the United States also negatively affects the demand in Hong Kong in the long run.

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APPENDICES

Appendix A. Definition of Variables

Variable	Description
Q_{us_ch}	Quantity of U.S. frozen chicken feet exports to CH and HK. (million kg)
Q_{us_cn}	Quantity of U.S. frozen chicken feet exports to China. (million kg)
Q_{us_hk}	Quantity of U.S. frozen chicken feet exports to Hong Kong. (million kg)
P_{us_ch}	Unit price of U.S. frozen chicken feet exports to CH and HK. (U.S. dollars)
P_{us_ch}	Unit price of U.S. frozen chicken feet exports to China. (U.S. dollars)
P_{us_ch}	Unit price of U.S. frozen chicken feet exports to Hong Kong. (U.S. dollars)
$Q_{broiler\_us}$	Total number of U.S. broilers slaughtered (million head)
P_{us_row}	Unit price of U.S. frozen chicken feet exports to ROW (U.S. dollars)
P_{bz_cn}	Unit price of Brazilian frozen fowl cut exports to China (U.S. dollars)
P_{bz_hk}	Unit price of Brazilian frozen fowl cut exports to Hong Kong (U.S. dollars)
P_{bro_cn}	Average monthly price of broilers for mainland China
P_{bro_hk}	Average monthly price of broilers for Hong Kong
GDP	Monthly GDP of aggregated market
GDP_{cn}	China's monthly GDP (billion Yuan)
GDP_{hk}	Hong Kong's monthly GDP (million HK$)
EXR	Monthly exchange rate from July 2007 to December 2011 (Yuans per dollar)
D_{break}	Dummy variable for the sudden policy change in October 2009
$D_{seasonal}$	Seasonal Dummy variable for feet consumption, April-October.

Appendix B. Estimated Excess Demand for Chicken Feet using GLS

Aggregate Market		Mainland China		Hong Kong	
$Q_{us\_ch,t}$	Coef.	$Q_{us\_cn,t}$	Coef.	$Q_{us\_hk,t}$	Coef.
$P_{us\_ch,t}$	-0.886** (0.392)	P_{us_cn}	-0.057 (0.924)	P_{us_hk}	-1.445** (0.712)
$P_{bro\_cn,t}$	0.039 (0.358)	$P_{bro\_cn,t}$	-1.106 (2.194)	$P_{bro\_hk,t}$	1.338*** (0.475)
$P_{bz\_ch,t}$	-0.024 (0.026)	$P_{bz\_cn,t}$	-0.099 (0.263)	$P_{bz\_hk,t}$	2.724*** (0.788)
GDP_t	0.197 (0.196)	GDPcn,t	0.378 (0.767)	GDPhk,t	1.143 (1.469)
EXR_t	-3.490** (1.596)	EXR_t	-12.815 (12.445)	EXR_t	1.468 (5.407)
D_{break}	0.171 (0.379)	D_{break}	-0.979 (0.909)	D_{break}	1.522** (0.618)
$D_{seasonal}$	0.195*** (0.044)	$D_{seasonal}$	0.035 (0.142)	$D_{seasonal}$	0.297*** (0.109)
INPT	15.470*** (1.605)	INPT	2.485 (8.938)	INPT	-10.962 (7.256)
Adj R-squared	0.789		0.070		0.592
Prob > F	0.000		0.171		0.000
Root MSE	0.120		0.371		0.281
RHO	0.179		0.889		0.562

Appendix C. Estimated Excess Supply for Chicken Feet using GLS

Aggregate market		Mainland China		Hong Kong	
$Q_{us\_ch,t}$	Coef.	Q_{us_cn}	Coef.	Q_{us_hk}	Coef.
$Q_{broiler\_us,t}$	1.385 (1.058)	$Q_{broiler\_us}$	1.968 (2.762)	$Q_{broiler\_us}$	1.879 (2.445)
$P_{us\_ch,t}$	-1.129** (0.484)	P_{us_cn}	0.030 (0.872)	P_{us_hk}	-1.475** (0.652)
P_{us_row}	0.024 (0.172)	P_{us_row}	-0.300 (0.375)	P_{us_row}	0.260 (0.329)
D_{break}	0.436 (0.401)	D_{break}	-0.972 (0.871)	D_{break}	0.656 (0.594)
INPT	17.504*** (0.452)	INPT	3.181*** (1.194)	INPT	3.252*** (1.178)
Adj R-squared	0.484		0.104		0.083
Prob > F	0.000		0.054		0.085
Root MSE	0.143		0.361		0.321
RHO	0.535		0.904		0.940

Appendix D. The Long-Run Excess Demand using ARDL (Aggregate Market)

Dep. Var.=$Q_{us\_ch,t}$	ARDL (3,2,1,0,3,0)
$P_{us\_ch, t}$	-1.138*** (0.366)
$P_{bro\_cn, t}$	-0.301 (0.442)
$P_{bz\_ch, t}$	-0.184 (0.118)
GDP_t	0.767** (0.321)
EXR_t	0.356 (1.628)
D_{break}	0.278 (0.320)
$D_{seasonal}$	0.361*** (0.081)
INPT	10.060*** (2.108)
R^2	0.702
F-statistic (bounds test)	4.971**

Appendix E. The Short-Run Excess Demand using ARDL (Aggregate Market)

Dep. Var.=$\Delta Q_{us\_ch,t}$	ARDL (3,2,1,0,3,0)
$\Delta Q_{us\_ch, t-1}$	0.257 (0.158)
$\Delta Q_{us\_ch, t-2}$	0.186* (0.107)
$\Delta P_{us\_ch,t}$	-0.851** (0.362)
$\Delta P_{us\_ch,t-1}$	0.506*** (0.185)
$\Delta P_{bro\_cn, t}$	-1.453 (0.876)
$\Delta P_{bz\_ch, t}$	-0.170 (0.106)
ΔGDP_t	0.570 (0.389)
ΔGDP_{t-1}	-1.959*** (0.511)
ΔGDP_{t-2}	0.428 (0.366)
ΔEXR_t	0.330 (1.489)
$\Delta D_{break, t}$	0.257 (0.302)
$\Delta D_{seasonal, t}$	0.333*** (0.057)
ECM t-1	-0.925*** (0.179)

Appendix F. The Long-Run Excess Supply using ARDL (Aggregate Market)

Dep. Var.=ln $Q_{us\_ch,t}$	ARDL(1,2,1,0)
$Q_{broiler\_us,t}$	-0.861 (1.417)
$P_{us\_ch,t}$	-1.512** (0.611)
$P_{us\_row,t}$	-0.168 (0.200)
D_{break}	-0.212 (0.285)
INPT	16.612*** (0.609)
R^2	0.529
F-statistic (bounds test)	5.761**

Appendix G. The Short-Run Excess Supply using ARDL (Aggregate Market)

Dep. Var.=Δ $Q_{us\_ch,t}$	ARDL(1,2,1,0)
$\Delta Q_{broiler\_us,t}$	2.012* (1.198)
$\Delta Q_{broiler\_us,t-1}$	2.487** (1.167)
$\Delta P_{us\_ch,t}$	-1.224*** (0.387)
$\Delta P_{us\_row,t}$	-0.128 (0.167)
ΔD_{break}	0.497 (0.323)
ECM t-1	-0.605*** (0.138)

Appendix H. The Long-Run Excess Demand using ARDL (Mainland China)

Dep. Var. = Q_{us_cn}	ARDL (3,3,2,0,0,0)	ARDL (1,3,2,0,0,0,0)	ARDL (3,3,2,0,0,0,0)
$P_{us\_cn,\ t}$	-3.437*** (1.067)	-3.088*** (1.143)	-3.726*** (0.866)
$P_{bro\_cn,\ t}$	-3.068* (1.144)	-2.801** (1.226)	-3.546*** (0.955)
$P_{bz\_cn,\ t}$	0.073 (0.317)	0.241 (0.336)	0.117 (0.264)
$GDP_{cn,\ t}$	0.008 (0.499)	0.581 (0.570)	0.528 (0.499)
EXR	-7.759* (4.222)	-8.296* (4.562)	-9.532** (3.544)
$Q_{us\_hk,t}$		-0.455** (0.172)	
$Q_{us\_hk,t-1}$			-0.259* (0.135)
D_{break}	0.655 (0.967)	0.688 (1.014)	1.173 (0.789)
$D_{seasonal}$	0.106 (0.176)	0.434** (0.194)	0.095 (0.145)
INPT	10.018*** (3.562)	5.447 (3.957)	11.054*** (2.947)
R^2	0.410	0.471	0.443
F-statistic (bounds test)	5.072**	4.276*	4.361*

Appendix I. The Short-Run Excess Demand using ARDL (Mainland China)

Dep.Var. = Q_{us_cn}	ARDL (3,3,2,0,0,0)	ARDL (1,3,2,0,0,0,0)	ARDL (3,3,2,0,0,0,0)
$\Delta Q_{us\_cn,t-1}$	0.242 (0.152)		0.278* (0.150)
$\Delta Q_{us\_cn,t-2}$	0.201 (0.145)		0.203 (0.141)
$\Delta P_{us\_cn,\ t}$	-1.597 (1.135)	-1.426 (1.003)	-2.291* (1.171)
$\Delta P_{us\_cn,\ t-1}$	1.603*** (0.477)	1.048** (0.391)	1.601*** (0.463)
$\Delta P_{us\_cn,\ t-2}$	1.160** (0.441)	0.931** (0.377)	1.191*** (0.428)
$\Delta P_{bro\_cn,\ t}$	0.890 (2.145)	2.010 (1.979)	0.141 (2.127)
$\Delta P_{bro\_cn,\ t-1}$	3.902* (2.268)	5.373** (2.208)	5.391** (2.360)
$\Delta P_{bz\_cn,\ t}$	0.067 (0.286)	0.190 (0.266)	0.125 (0.280)
$\Delta GDP_{cn,\ t}$	0.007 (0.452)	0.457 (0.447)	0.560 (0.540)
ΔEXR_t	-7.024 (4.455)	-6.531 (3.996)	-10.119** (4.672)
$\Delta Q_{us\_hk,t}$		-0.358** (0.138)	
$\Delta Q_{us\_hk,\ t-1}$			-0.275* (0.157)
ΔD_{break}	0.593 (0.961)	0.541 (0.859)	1.245 (1.005)
$\Delta D_{seasonal}$	0.096 (0.146)	0.341*** (0.122)	0.101 (0.142)
ECMt-1	-0.905*** (0.203)	-0.787*** (0.155)	-1.062*** (0.217)

Appendix J. The Long-Run Excess Supply using ARDL (Mainland China)

Dep.Var.= $Q_{us\_cn,t}$	ARDL (1,2,3,0)	ARDL (1,2,3,0,0)	ARDL (1,2,3,0,0)
$Q_{broiler\_us,t}$	-2.700 (3.076)	-2.625 (2.722)	-2.004 (2.891)
$P_{us\_cn,t}$	-2.721* (1.502)	-3.409** (1.336)	-3.128* (1.395)
$P_{us\_row,t}$	-1.184 (0.726)	-1.212* (0.643)	-1.048 (0.674)
$Q_{us\_hk, t}$		-0.335 (0.204)	
$Q_{us\_hk, t-1}$			-0.218 (0.205)
D_{break}	0.056 (1.261)	1.096 (1.208)	0.656 (1.242)
INPT	1.350 (1.333)	1.663 (1.204)	4.802 (3.516)
R^2	0.370	0.392	0.370
F-statistic (bounds test)	5.373**	4.591*	4.205*

Appendix K. Short-Run Excess Supply using ARDL (Mainland China)

Dep.Var.=$\Delta Q_{us\_cn,t}$	ARDL (1,2,3,0)	ARDL (1,2,3,0,0)	ARDL (1,2,3,0,0)
$\Delta Q_{broiler\_us,t}$	1.892 (2.733)	2.751 (2.739)	2.111 (2.742)
$\Delta Q_{broiler\_us,t-1}$	6.844** (2.702)	7.936*** (2.743)	7.452*** (2.770)
$\Delta P_{us\_cn,t}$	-0.874 (0.794)	-1.480* (0.870)	-1.195 (0.856)
$\Delta P_{us\_cn,t-1}$	0.962 (0.414)	0.906** (0.408)	0.941** (0.415)
$\Delta P_{us\_cn,t-2}$	0.912 (0.425)	0.974** (0.419)	0.896** (0.425)
$\Delta P_{us\_row,t}$	-0.652 (0.406)	-0.741* (0.403)	-0.630 (0.407)
$\Delta Q_{us\_hk,\ t}$		-0.205 (0.130)	
$\Delta Q_{us\_hk,\ t-1}$			-0.131 (0.131)
ΔD_{break}	0.031 (0.698)	0.670 (0.797)	0.394 (0.787)
ECM t-1	-0.551*** (0.126)	-0.612*** (0.130)	-0.601*** (0.136)

Appendix L. The Long-Run Excess Demand using ARDL (Hong Kong)

Dep. Var. = Q_{us_hk}	ARDL (1,2,,2,1,0,0)	ARDL (1,2,3,1,0,0,3)	ARDL (1,2,0,1,3,0,0)
$P_{us\_hk, t}$	-1.729** (0.749)	-1.630** (0.657)	-1.858** (0.723)
$P_{bro\_hk, t}$	1.385*** (0.457)	0.888 (0.588)	0.856 (0.583)
$P_{bz\_hk, t}$	1.096* (0.646)	0.671 (0.598)	0.634 (0.595)
$GDP_{hk, t}$	-0.281 (1.101)	0.071 (0.973)	-0.040 (0.965)
EXR	3.767 (3.146)	4.544 (3.024)	4.397 (2.989)
$Q_{us\_cn,t}$		-0.157* (0.090)	
$Q_{us\_cn, t-1}$			-0.140 (0.086)
D_{break}	2.266*** (0.639)	1.919*** (0.547)	2.160*** (0.551)
$D_{seasonal}$	0.457*** (0.108)	0.570*** (0.108)	0.515*** (0.103)
INPT	-3.894 (5.280)	-2.899 (4.762)	-0.371 (5.331)
R^2	0.735	0.755	0.751
F-statistic (bounds test)	14.022**	13.944**	12.850**

Appendix M. The Short-Run Excess Demand using ARDL (Hong Kong)

Dep. Var=Q_{us_hk}	ARDL (1,2,2,1,0,0)	ARDL (1,2,3,1,0,0,3)	ARDL (1,2,0,1,3,0,0)
$\Delta P_{us\_hk, t}$	-1.975*** (0.483)	-1.889*** (0.482)	-2.050*** (0.512)
$\Delta P_{us\_hk, t-1}$	-0.851*** (0.229)	-0.733*** (0.248)	-0.836*** (0.235)
$\Delta P_{bro\_hk, t}$	1.466*** (0.328)	1.618*** (0.364)	1.628*** (0.367)
$\Delta P_{bro\_hk, t-1}$	0.793** (0.327)	1.356*** (0.400)	1.389*** (0.412)
$\Delta P_{bro\_hk, t-2}$		0.516 (0.345)	0.632* (0.363)
$\Delta P_{bz\_hk, t}$	3.736*** (0.596)	4.012*** (0.632)	4.128*** (0.640)
$\Delta GDP_{hk, t}$	-0.193 (0.748)	0.552 (0.757)	-0.032 (0.767)
ΔEXR_t	2.592 (2.152)	17.794** (8.443)	19.388** (8.858)
ΔEXR_{t-1}		8.012 (7.509)	11.367 (8.025)
ΔEXR_{t-2}		-11.462 (8.612)	-12.433 (8.649)
$\Delta Q_{us\_cn,t}$		-0.121 (0.073)	
$\Delta Q_{us\_cn, t-1}$			-0.112 (0.074)
ΔD_{break}	1.559*** (0.413)	1.487*** (0.402)	1.720*** (0.439)
$\Delta D_{seasonal}$	0.314*** (0.075)	0.442*** (0.089)	0.410*** (0.085)
ECMt-1	-0.688*** (0.088)	-0.775*** (0.091)	-0.796*** (0.098)

Appendix N. The Long-Run Excess Supply using ARDL (Hong Kong)

Dep. Var.=$Q_{us\_hk,t}$	ARDL (1,1,2,0)	ARDL (1,1,0,2,0)	ARDL (1,1,2,2,1)
$Q_{broiler\_us,t}$	-8.561 (5.493)		-8.726 (5.907)
$P_{us\_hk,t}$	-3.198* (1.760)		-3.088 (2.022)
$P_{us\_row,t}$	-0.626 (0.841)		-0.722 (1.310)
$Q_{us\_cn,t}$			0.108 (0.254)
$Q_{us\_cn,t-1}$			
D_{break}	3.855*** (1.308)		4.038*** (1.407)
INPT	-2.117 (2.262)		-4.020 (4.811)
R^2	0.372	0.359	0.391
F-statistic (bounds test)	7.125**	3.005 (indecisive)	5.220**

Appendix O. The Short-Run Excess Supply using ARDL (Hong Kong)

Dep. Var.=$\Delta Q_{us\_hk,t}$	ARDL (1,1,2,0)	ARDL (1,1,0,2,0)	ARDL (1,1,2,2,1)
$\Delta Q_{broiler\_us,t}$	0.272 (2.700)	0.540 (2.655)	1.226 (2.821)
$\Delta P_{us\_hk,t}$	-2.112*** (0.653)	-2.067*** (0.664)	-2.085*** (0.659)
$\Delta P_{us\_hk,t-1}$	-0.733** (0.355)		-0.683* (0.400)
$\Delta P_{us\_row,t}$	-0.270 (0.349)	-0.119 (0.361)	-0.151 (0.362)
$\Delta P_{us\_row,t-1}$		-0.717** (0.333)	-0.469 (0.360)
$\Delta Q_{us\_cn,\ t}$		-0.081 (0.092)	
$\Delta Q_{us\_cn,\ t-1}$			-0.133 (0.133)
ΔD_{break}	1.665*** (0.542)	1.746*** (0.522)	1.627*** (0.549)
ECM t-1	-0.432*** (0.098)	-0.387*** (0.099)	-0.403*** (0.105)

Appendix P. Estimated Excess Demand using 2SLS

Aggregate Market		Mainland China		Hong Kong	
Q_{us_ch}	Coef.	ΔQ_{us_ch}	Coef.	ΔQ_{us_ch}	Coef.
ΔP_{us_ch}	-2.011 (6.427)	ΔP_{us_cn}	3.111 (5.708)	ΔP_{us_hk}	0.982 (3.382)
ΔP_{bro_cn}	0.522 (2.171)	ΔP_{bro_cn}	3.014 (3.564)	ΔP_{bro_hk}	0.551 (0.766)
ΔP_{bz_ch}	-0.089 (0.162)	ΔP_{bz_cn}	-0.047 (0.145)	ΔP_{bz_hk}	2.418* (1.254)
ΔGDP	1.866* (0.994)	ΔGDP_{cn}	1.166 (0.973)	ΔGDP_{hk}	2.828 (4.696)
ΔEXR	-6.489*** (2.305)	ΔEXR	-2.997 (3.017)	ΔEXR	-0.147 (3.339)
ΔD_{break}	1.253 (5.552)	ΔD_{break}	-3.593 (5.052)	ΔD_{break}	-1.100 (2.611)
$\Delta D_{seasonal}$	-0.034 (0.174)	$\Delta D_{seasonal}$	0.144 (0.196)	$\Delta D_{seasonal}$	0.279** (0.151)
INPT	17.268*** (0.040)		-0.070 (0.052)		0.010 (0.050)
R-squared	0.264		0.000		0.116
Prob > Chi2	0.000		0.000		0.000
Root MSE	0.254		0.386		0.316

Appendix Q. Estimated Excess Supply using 2SLS

Aggregate Market		Mainland China		Hong Kong	
Q_{us_ch}	Coef.	ΔQ_{us_cn}	Coef.	ΔQ_{us_hk}	Coef.
$\Delta Q_{broiler\_us}$	-4.011 (3.224)	$\Delta Q_{broiler\_us}$	-1.156 (2.520)	$\Delta Q_{broiler\_us}$	-0.102 (1.688)
ΔP_{us_ch}	2.572 (2.614)	ΔP_{us_cn}	0.929 (2.826)	ΔP_{us_hk}	3.060 (3.055)
ΔP_{us_row}	-0.021 (0.278)	ΔP_{us_row}	-0.300 (0.341)	ΔP_{us_row}	0.153 (0.374)
ΔD_{break}	3.178 (2.840)	ΔD_{break}	0.290 (2.296)	ΔD_{break}	-0.454 (1.274)
INPT	17.296*** (0.046)	INPT	-0.037 (0.048)	INPT	0.038 (0.044)
R-squared	0.000		0.089		0.088
Prob > Chi2	0.000		0.000		0.000
Root MSE	0.330		0.352		0.321