A Marketing Analysis of U.S. Chicken Exports to China

Li Zhang and Lewell Gunter

Former graduate research assistant and Professor, respectively,
Dept. Agricultural and Applied Economics, University of Georgia, Athens, GA

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The U.S. poultry industry is the world's largest producer and exporter of poultry meat. U.S. broiler production is concentrated in Georgia, Arkansas, North Carolina, Alabama, and Mississippi. In 2001, these States accounted for over 67 percent of U.S. broilers produced (USDA,NASS).

U.S. poultry exports are primarily chicken and turkey, with chicken exports 10 times as large as the volume of turkey exports. In 2001, U.S. broiler exports totaled 5.6 billion pounds (18 percent of total production), valued at $1.8 billion. The major U.S. broiler export markets are Russia and Hong Kong/China. The other smaller markets include Korea, Japan, Canada and Mexico (USDA,FAS,c).

From 1997 to 2001, the total value of U.S. frozen chicken parts exports to Russia was $2.2 billion, and $1.72 billion to Hong Kong/China. In 2001, these largest two importers accounted for 59 percent of total shipments of U.S. broiler products, on a quantity basis. As markets have opened to increased poultry trade, the United States has benefited by selling chicken breasts in the domestic market and exporting dark meat and less valuable cuts to other markets where they are preferred over breast meat. This strategy has been especially beneficial for the United States, as large markets have developed for leg meat in Russia and wings, wing tips, and feet in Hong Kong and China (USITC).

Figure 1 shows the value of U.S. chicken meat exports to key importers from 1997-2001. The highest valued chicken export category is frozen chicken parts (HTS code: 020714) for all the top import countries listed in the graph, except for Canada. In this study, we will focus on the trade of frozen chicken parts. From 1997 to 2001, the total value of Russia's frozen chicken parts imports was $ 2.2 billion, followed by Hong Kong/China (HKC) at $1.72 billion. These two markets accounted more than 60 percent of the world imports of U.S. frozen chicken parts (USITC).

Under HTS category 020714, frozen chicken parts are further divided into five categories: chicken leg quarters , chicken legs excluding leg quarters, chicken wings, chicken feet, chicken offal, and others. Figure 2 shows the total value of exports of U.S. frozen chicken by part and country for 1997-2001. Russia's imports are mostly chicken leg quarters, and HKC's top imports are chicken feet. Note that Hong Kong is the leading importer of chicken feet, legs, wings, and offal, and this makes Hong Kong

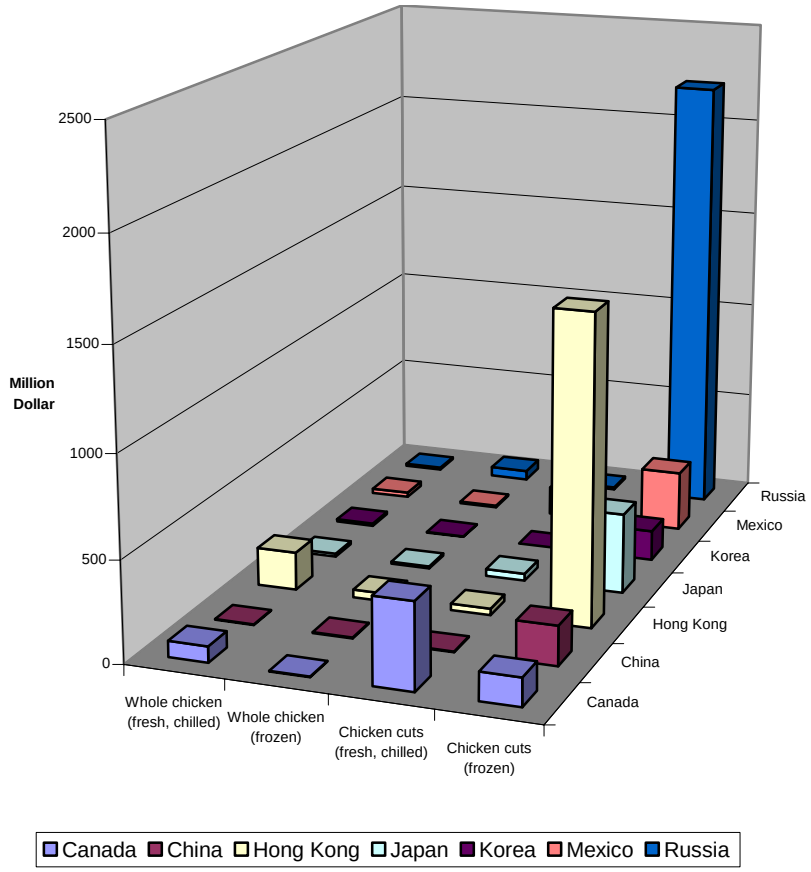

Figure 1. U.S. Chicken Exports to Key Importers (1997-2001 Total)

Source: USITC (The United States International Trade Commission) Interactive Tariff and Trade Dataweb. Webpage: http://dataweb.usitc.gov/.

the second largest importer of U.S. chicken, trailing only Russia. Comparing the exports to Hong Kong and Russia, we can see that Hong Kong's chicken imports are of more variety, and in general, the parts exported to Hong Kong are different from those exported to Russia, thus, these two biggest importers are occupying different U.S. chicken part markets.

Chicken Meat Demand in China

U.S. broiler parts are extremely competitive in China, accounting for over 60 percent of total poultry imports. For the past decade, Chinese poultry meat consumption has grown at a double-digit pace. China promises to be an important and growing market for poultry meat in the future. A population 10 times as large as Russia, an expanding middle class, and relative low per capita consumption levels

suggest that consumption will continue to grow. The rapid growth of the fast-food sector, shift in consumer preferences away from pork towards poultry, and the booming of supermarkets and hypermarkets, will accelerate the growth of chicken meat demand (USDA,FAS,a,b).

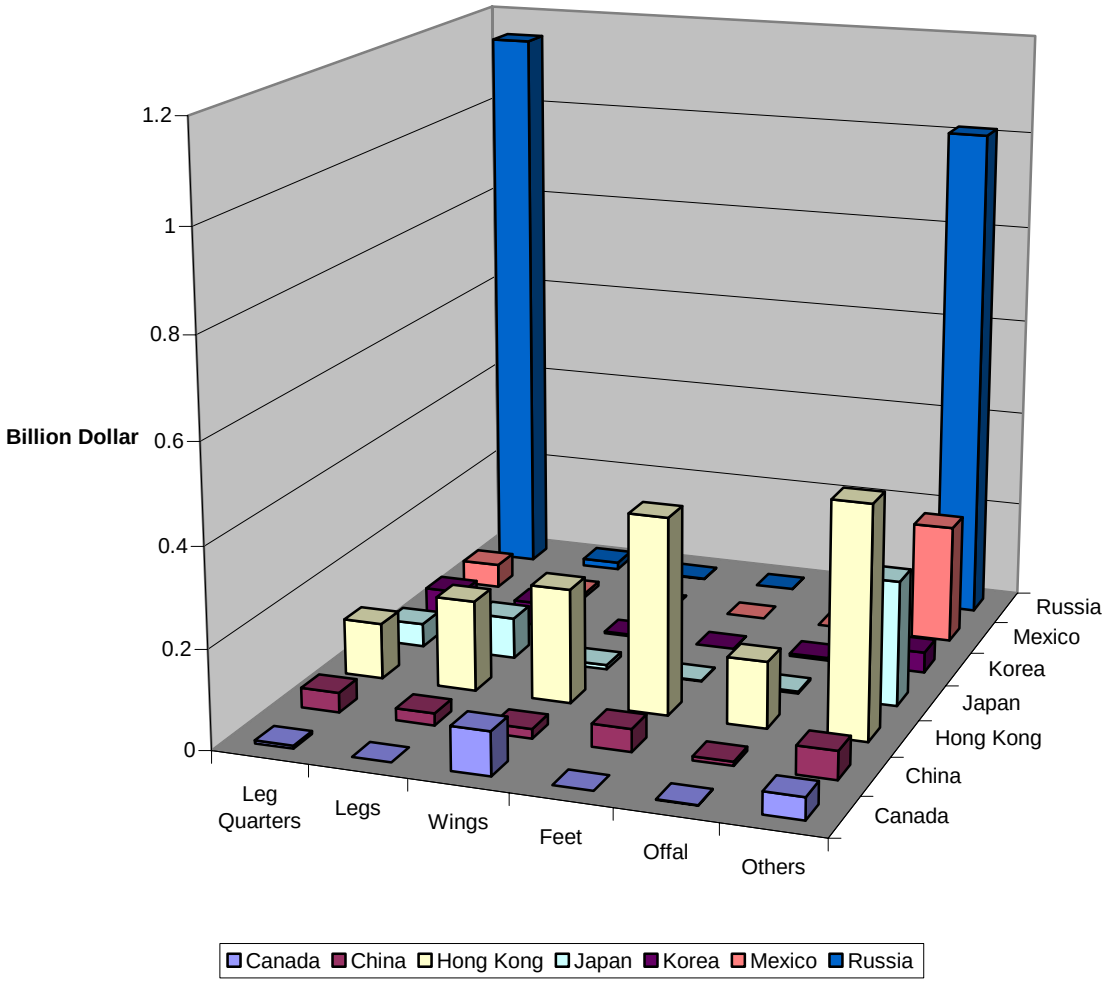

Figure 2. U.S. Frozen Chicken Parts Exports (1997-2001 Total)

Source: USITC (The United States International Trade Commission) Interactive Tariff and Trade Dataweb. Webpage: http://dataweb.usitc.gov/.

Less than a third of China's poultry meat imports are direct, with the rest transshipped through Hong Kong, because Hong Kong is a free port and does not levy customs tariffs on imports, and there is also no tariff quota or surcharge. Hong Kong's chicken meat re-exports to Mainland China is the real factor that causes the changes of Hong Kong's total imports. Now that China has entered the WTO,

reductions of duties and the easing of improper import restrictions will make Shanghai, Dalian, Tianjin and other mainland ports attractive entry points. For the foreseeable future, trade will continue through Hong Kong. Because almost 70 percent of Hong Kong's imports are re-exported to China, and China's direct imports are of very little volume compared to Hong Kong's imports, it's informative to focus on combined Hong Kong/China imports (USDA,FAS,a,b).

Brazil is the world's second largest broiler exporter. It is also the second largest poultry supplier for the Hong Kong market. Brazil is very strong in the supply of its 3-joint wings and whole birds to Hong Kong. Brazil broiler production and exports have been increasing during the past decade, due to, devaluation of the Brazilian currency, increase in average slaughter weight, low cost of production and improved productive capacity (USDA,FAS,a,b).

Figure 3 shows the annual exports of U.S. frozen chicken parts to HKC from 1997 to 2001. It can be seen that chicken feet has always been a major component of U.S. chicken parts exports, and its export volume increased from 0.118 million MT in 1997 to 0.280 million MT in 2001. Chicken legs, wings, and offal exports also increased markedly since 1997. Note that due to Russia's economic crisis in 1999, Hong Kong imported significantly more chicken leg quarters in 1999, and decreased its imports after Russia's economic recovery in 2000 (USITC).

While growth in exports to the HKC market has benefited the U.S. broiler industry, the trend has not strengthened prices as dramatically as it would in other markets. The reason lies in the composition of products shipped to HKC. More than 20 percent of all broiler products exported there consist of chicken feet. Without this market, almost all of these parts would go to renderers for eventual use as feedstuff. These exports represent a definite gain to broiler processors, but their absence from the U.S. domestic market does not affect prices for broiler parts traditionally consumed in the U.S.

Objectives

The major objectives of this study are to examine the HKC market for U.S. chicken products and to model the excess supply and excess demand of U.S. chicken exported to HKC. The following analysis

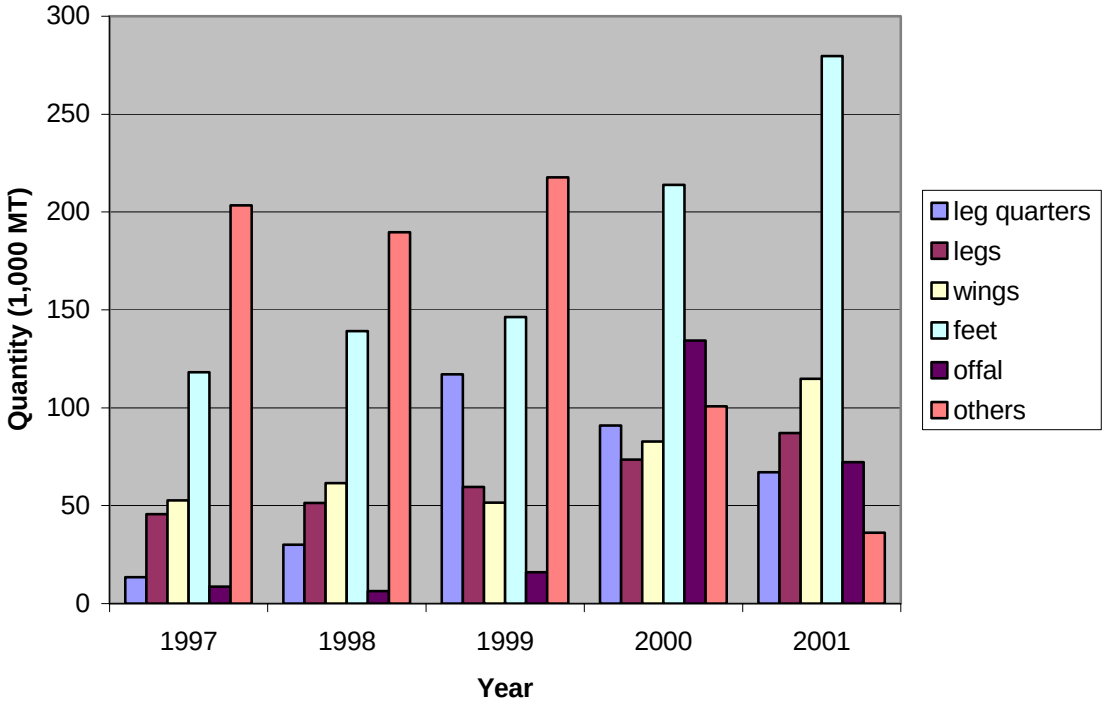

Figure 3. U.S. Frozen Chicken Parts Annual Exports to Hong Kong/China
Source: USITC (The United States International Trade Commission) Interactive Tariff and Trade Dataweb. Webpage: http://dataweb.usitc.gov/.

will focus on two aspects of the market: the excess supply of U.S. product to HKC, and the excess demand for U.S. frozen chicken parts in HKC. In this study, we want to find out what factors affect the excess supply and excess demand of U.S. broiler meat exports to China.

The Empirical Model

Four chicken products were analyzed in the empirical model. They are: frozen chicken legs, wings, feet, and offal. ES/ED of frozen chicken leg quarters were not estimated in this analysis because Russia is the dominant market for U.S. chicken leg quarters. However, before specifying factors affecting excess supply and demand in the relevant countries, the joint product nature of the production of different frozen chicken parts must be considered.

U.S. excess production of some chicken parts may be caused by the domestic demand for chicken breast meat, which sells at much higher price than whole chicken, or other chicken parts. The production

of all the chicken parts is primarily determined by production of whole birds which is largely determined by domestic demand for chicken breast meat. Because chicken parts are produced in fixed proportion per bird, more chicken feet, offal, legs, wings, etc. may be produced than needed in the U.S. domestic market, and U.S. producers may have to find foreign markets to clear these "residual products." HKC is by far the largest user of these residual chicken parts.

It is assumed that U.S. chicken meat is distributed to: the U.S., HKC, and ROW. It is also assumed that chicken consumed in HKC is produced domestically, imported from the U.S., or imported from ROW. Thus, the excess supply (ES) of frozen chicken part j from U.S. to HKC, where j is one of the parts which is produced in fixed proportion per bird, can be specified as a function of U.S. chickens produced and prices of part j in alternate markets,

$$Q^{sj}_{US\text{-}HKC,\,t} = f(Q_{US,\,t},\ P^{j}_{US,\,t},\ P^{j}_{US\text{-}HKC,\,t},\ P^{j}_{US\text{-}ROW,\,t}) \qquad (1)$$

where

$Q^{sj}_{US\text{-}HKC,\,t}$ = Quantity of U.S. frozen chicken part j exported to HKC in period t.

$Q_{US,\,t}$ = Number of chickens slaughtered in the U.S in period t.

$P^{j}_{US,\,t}$ = U.S. domestic price of chicken part j in period t.

$P^{j}_{US\text{-}HKC,\,t}$ = Value per unit of U.S. frozen chicken part j exported to HKC in period t.

$P^{j}_{US\text{-}ROW,\,t}$ = Value per unit of U.S. frozen chicken part j exported to ROW in period t.

The excess demand (ED) for U.S. frozen chicken part j in HKC is specified as a function of own-price, HKC income, and prices of related goods (including part j from other countries). Specifically,

$$Q^{dj}_{US\text{-}HKC,\,t} = f(P^{j}_{US\text{-}HKC,\,t},\ P^{j}_{HKC,\,t},\ P^{alt}_{HKC,\,t},\ Income_{HKC,\,t},\ P^{j}_{ROW\text{-}HKC,\,t}) \qquad (2)$$

where

$Q^{dj}_{US\text{-}HKC,\,t}$ = Quantity of frozen chicken part j imported by HKC in period t.

$P^{j}_{US\text{-}HKC,\,t}$ = Price of U.S. frozen chicken part j imported by HKC in period t.

$P^{j}_{HKC,\,t}$ = Price of chicken part j produced in Hong Kong/China in period t.

$P^{alt}_{HKC,\,t}$ = Price of alternative meat product in Hong Kong/China market in period t.

$Income_{HKC,\,t}$ = Hong Kong/China income level in period t.

$P^{j}_{ROW\text{-}HKC,\,t}$ = Price of ROW frozen chicken part j imported by HKC in period t.

Both the Hong Kong dollar and the China RMB are pegged to the US dollar, and the exchange rates of the Hong Kong dollar and China RMB to the U.S. dollar are almost fixed during the study period. Because of the absence of variation in these exchange rates, they were not included in the model.

Data

The models in this study employed monthly data from January 1997 through December 2000. Trade data were obtained from the United States International Trade Commission (USITC). U.S. broiler meat production and U.S. domestic price data are obtained from Poultry Yearbook, USDA. U.S. chicken parts price data are from "Economic Time Series Page", www.economagic.com. Hong Kong live chicken price and Hong Kong GDP data are from Census & Statistics Department, Hong Kong SAR Government. Brazil export data are obtained from the Brazilian Poultry Exporters Association website: http://www.abef.com.br/.

Estimated Models

The model was estimated using several functional forms to examine the robustness of the estimates, and four model specifications were estimated in this study. These specifications are presented in the next sections. The estimates of structural parameters of each specification were obtained by estimating these eight equations simultaneously, except for specification 3, where parameters were estimated for each chicken part separately. The empirical models estimated are further refined from the general form functions (1 and 2). Some refinements/modifications are discussed in the following sections.

Model Refinements/Modifications

There are some modifications of the model, due to the data availability. (1) In the ES equations for feet and offal, the U.S. price, P^{j}_{us}, was not included as an explanatory variable because there is no market in the U.S. for chicken feet and offal. (2) In the ED equations, the variable, P^{j}_{HKC}, price of chicken parts produced in HKC was not included because the monthly data were not available. The Hong Kong Composite Consumer Price Index for live poultry, P_{HK_live}, was used as a proxy for P^{alt}_{HKC}. This price information can safely be extended to the HKC market, because commodity prices in Hong Kong and

Mainland China markets are closely related. (3) The price of HKC imports from ROW ($P^{j}_{ROW\text{-}HKC}$) was not available. In order to account for the impact of HKC imports from non-U.S. sources on the HKC demand for U.S. chicken, we included an alternative variable, Q_{Brazil}, which is the quantity of Brazil chicken product exported. We chose Q_{Brazil} because Brazil is a major exporter to HKC. (4) HKC income data, $Income_{HKC}$, are also unavailable, so Hong Kong GDP, GDP_{hk}, was used as a proxy for HKC income. (5) a Chinese domestic chicken production variable is not in the model specification, because these data are unavailable. Demand for U.S. imports may not be affected by Chinese production at recent production levels, however. Also, the exported products from the U.S. do not compete directly with China's domestic supply due to Chinese consumption habits, and Chinese domestic producers cannot satisfy the demand for these chicken parts without imports. Leaving out Chinese chicken production is not expected to result in serious bias in the estimates. (6) The variable, $Q^{leg\ quarter}_{US\text{-}HKC}$ ($Q^{leg\ qrt}_{US\text{-}HKC}$), was added to the ED equations in order to capture the influence of leg quarter imports on the demand for other chicken parts. This variable was treated as an exogenous variable in estimation because the quantity of chicken leg quarters shipped to HKC appears to be largely determined by the quantity of U.S. leg quarters diverted from Russia when their imports were sharply reduced.

We also noted that U.S.-HKC chicken export data changed dramatically since January 2000. The quantity of "other" chicken parts was only half of its volume before January 2000, and the quantity of chicken offal was ten times as large as before. We suspect that the changes on the quantity of different chicken parts exports were caused by changes in the classification of chicken parts. Thus, we defined the dummy variable, d_y2, with the value 0 for the observations of year 1997-1999, and 1 for the year 2000. Because the magnitude of the data problem was related to the data of export quantity of "other" chicken part, an interaction term, D1, was defined by multiplying $Q^{others}_{US\text{-}HKC}$ with the dummy variable d_y2, and D1 was added to the ES and ED equations as an adjustment term. There were 45 total observations in this study. A 3-month moving average smoothing method was applied to the original data to reduce some of the seasonal variations in the data.

Model Specifications

Several different approaches were employed to specify the ES equations for empirical estimation. Specifically, linear price, price ratio, and no price approaches were examined in this study. Each of these specifications will be discussed in the following sections.

Linear Price Approach (Specification 1)

In the linear price approach, the supply of exports is specified as a function of U.S. chicken production, the HKC export price, U.S. price, ROW export price, and an adjustment term, D1. The equation for the excess supply of U.S. frozen chicken part j was specified as:

$$Q^{j}_{US\text{-}HKC} = a_0 + a_1 Q_{US} + a_2 P^{j}_{US\text{-}HKC} + a_3 P^{j}_{US} + a_4 P^{j}_{US\text{-}ROW} + a_5 D1 + \varepsilon_{1t}. \qquad (3)$$

Equation (3) embodies the hypothesis that exports to HKC are posited to rise when there's an increase in the U.S. production. In addition, as the price of HKC exports rises, exports to HKC become more profitable and, hence, exporters will supply more. As the price in U.S. or the price of exports to ROW rise, exports to HKC become relatively less profitable and, hence, exporters will supply less. We, therefore, expect a_1 and a_2 to be positive in the results, and a_3 and a_4 to be negative.

The Hong Kong/China inverse excess demand equation was specified as:

$$P^{j}_{US\text{-}HKC} = b_0 + b_1 Q^{j}_{US\text{-}HKC} + b_2 Q^{\text{leg quarter}}_{US\text{-}HKC} + b_3 P_{HK\_live} + b_4 GDP_{HK} + b_5 Q_{Brazil} + b_6 D1 + \varepsilon_{2t}, \qquad (4)$$

where j = chicken feet, chicken wings, chicken leg, and chicken offal, and $\varepsilon_{1t,}$ ε_{2t} = disturbance terms. The ε_ts were assumed to satisfy the assumptions of the classical normal linear regression model.

Equation (4) embodies the hypothesis that as the quantity of HKC imports rises, prices of the imports will become lower in order to clear the HKC market. In addition, import prices are posited to rise, when there is an increase in the Hong Kong GDP. We therefore expect b_1 to be negative and b_4 to be positive in the results. Since $Q^{\text{leg quarter}}_{US\text{-}HKC}$ and Q_{Brazil} represent quantities of substitutes for frozen imported parts from the U.S. We expect b_2 and b_5 to be negative. Since P_{HK_live} represents the price of a substitute for U.S. frozen chicken parts, we expect b_3 to be positive. ES equations (3) and ED equations (4) comprised the system model for specification 1. The endogenous variables in ES and ED system

models are: $Q^{j}_{US\text{-}HKC}$ and $P^{j}_{US\text{-}HKC}$, and the exogenous variables are: Q_{US}, P^{j}_{US}, $P^{j}_{US\text{-}ROW}$, $Q^{leg\ quarter}_{US\text{-}HKC}$, P_{HK_live}, GDP_{HK}, Q_{Brazil}, and D1.

In the above model specification, we have a set of ES and ED equations for each chicken part, and there are four chicken parts of interest. The price and quantity of chicken parts traded are to be determined jointly in the market. For this specification, we used three-stage least squares.

Price Ratio Approach (Specifications 2 and 3)

The differences between the price ratio approach and the linear price approach are in the specification of the ES equations. In this approach, the relative prices were used in model specification. Two versions of the price ratio approach are examined in this study.

Specification 2

The supply of exports is specified as a function of U.S. chicken production, price of U.S. exports to HKC, the relative prices of exports (i.e., the ratio of the U.S. domestic price to the HKC export price, and the ratio of the ROW export price to the HKC export price), and an adjustment term, D1. The excess supply equation and the inverse excess demand of U.S. frozen chicken part j were specified as:

$$Q^{j}_{US\text{-}HKC} = c_0 + c_1 Q_{US} + c_2 P^{j}_{US\text{-}HKC} + c_3 P^{j}_{US}/P^{j}_{US\text{-}HKC} + c_4 P^{j}_{US\text{-}ROW}/P^{j}_{US\text{-}HKC} + c_5 D1 + \varepsilon_{3t.} \quad (5)$$

$$P^{j}_{US\text{-}HKC} = d_0 + d_1 Q^{j}_{US\text{-}HKC} + d_2 Q^{leg\ quarter}_{US\text{-}HKC} + d_3 P_{HK\_live} + d_4 GDP_{HK} + d_5 Q_{Brazil} + d_6 D1 + \varepsilon_{4t.} \quad (6)$$

The ED equation (6) is the same as that in specification 1. Equations (5) and (6) comprise the system model of specification 2. The setting of endogenous variables and exogenous variables for specification 2 is the same as that in specification 1.

Note that the excess supply equations in specification 2 are nonlinear in variables. These nonlinear variables are price ratios $P_{US}/P^{j}_{US\text{-}HKC}$ and $P^{j}_{US\text{-}ROW}/P^{j}_{US\text{-}HKC}$. We need a method that can estimate simultaneous models with nonlinear equation. Here we used i3sls (iterated three-stage least squares) estimation. Starting with an initial value for the parameter values, nonlinear i3sls tries different parameter

values until the objective function of the estimation method is minimized. In specification 2, each set of ES and ED equations for a chicken part was estimated separately, to avoid the convergence problem. Initially, all 8 equations were estimated simultaneously, but the i3sls estimation did not converge.

Specification 3

Specification 3 is similar to specification 2 in that they have the same appearance of excess supply and demand equations, but the model of specification 3 is estimated in another way. Although the price ratios $P^j_{US} / P^j_{US\text{-}HKCH}$ and $P^j_{US\text{-}ROW} / P^j_{US\text{-}HKCH}$ are still in the ES equations, these price ratios were calculated before estimation and were treated as predetermined. Thus, specification 3 is estimated by 3sls instead of i3sls. This is the only difference between specifications 2 and 3.

No Price Approach (Specification 4)

To investigate the notion that the U.S. treats HKC as a place to dispose of surplus chicken parts, we added a specification which has no prices in the ES equations. In the absence of $P^j_{US\text{-}HKCH}$, P^j_{US} and $P^j_{US\text{-}ROW}$ in the ES equation, the supply of exports is specified as a function of the U.S. chicken production and an adjustment term of D1. On theoretical grounds, the first three specifications are less restrictive in that they include prices or relative prices in the models. The equation for the excess supply of U.S. frozen chicken part j was specified as:

$$Q^j_{US\text{-}HKC} = e_0 + e_1 Q_{US} + e_2 D1 + \varepsilon_{5t.} \qquad (7)$$

The 3sls estimation method was applied on this specification. A summary of the variables used in the various specifications of the econometric model is presented in Table 1.

Results

Overall, the results (Tables 2-5) suggest that the changes in the exports of U.S. frozen chicken parts to HKC are attributable to changes in U.S. chicken production. Furthermore, prices of these exports are negatively impacted by the quantity exported and the diversion of leg quarters from Russia to HKC, and positively impacted by income increases in Hong Kong. Results also reveal that lower import prices are associated with higher quantities of U.S. exports, for most of the chicken parts.

Table 1. Variable Definitions

Variable	Definition
$Q^{leg}_{US\text{-}HKC}$	Quantity of the U.S. domestic exports of frozen chicken legs to Hong Kong/China. (In 1,000 MT)
$Q^{wing}_{US\text{-}HKC}$	Quantity of the U.S. domestic exports of frozen chicken wings to Hong Kong/China. (In 1,000 MT)
$Q^{feet}_{US\text{-}HKC}$	Quantity of the U.S. domestic exports of frozen chicken feet to Hong Kong/China. (In 1,000 MT)
$Q^{offal}_{US\text{-}HKC}$	Quantity of the U.S. domestic exports of frozen chicken offal to Hong Kong/China. (In 1,000 MT)
$Q^{other}_{US\text{-}HKC}$	Quantity of the U.S. domestic exports of other frozen chicken parts[d] to Hong Kong/China. (In 1,000 MT)
$P^{leg}_{US\text{-}HKC}$	Price[a] of the U.S. domestic exports of frozen chicken legs to Hong Kong/China. (U.S. dollar/Kg)
$P^{wing}_{US\text{-}HKC}$	Price[a] of the U.S. domestic exports of frozen chicken wings to Hong Kong/China. (U.S. dollar/Kg)
$P^{feet}_{US\text{-}HKC}$	Price[a] of the U.S. domestic exports of frozen chicken feet to Hong Kong/China. (U.S. dollar/Kg)
$P^{offal}_{US\text{-}HKC}$	Price[a] of the U.S. domestic exports of frozen chicken offal to Hong Kong/China. (U.S. dollar/Kg)
$P^{other}_{US\text{-}HKC}$	Price[a] of the U.S. domestic exports of other frozen chicken parts[b] to Hong Kong/China. (U.S. dollar/Kg)
Q_{US}	Number of total chicken slaughtered in U.S.
P^{leg}us	US chicken leg domestic (North East) price (cents/pound)
P^{wing}us	US chicken wing domestic (North East) price (cents/pound)
$Q^{leg\ qrt}_{US\text{-}HKC}$	Quantity of the U.S. domestic exports of frozen chicken leg quarters to Hong Kong/China. (In 1,000 MT)
P_{HK_live}	Hong Kong live poultry Composite Consumer Price Index (Oct. 1999-Sep. 2000=100)
GDP_{HK}	Hong Kong Seasonal Gross Domestic Product (HK$ million)
Q_{Brazil}	Brazil chicken product exports to the whole world.
d_y2	Dummy variable, with the value equals to 1 for the year 2000, and equals to 0 otherwise.
D1	Interaction term of d_y2 and $Q^{other}_{US\text{-}HKC.}$

[a] domestic export value/domestic export quantity (USITC)

In general, the ED results were much more robust across specifications with more significant coefficients of expected signs. ES results were more variable across specifications with more insignificant coefficients or unexpected signs (Tables 2-5). In the following discussion, we will focus primarily on those estimated parameters which are significantly different from zero at the 10 percent level.

Table 2. Estimation Results for U.S. Chicken Feet Exports to HKC (1997-2000)

Variable	Linear Prices		Relative Prices[a]		Relative Prices[a,b]		No Prices	
Excess Supply: $Q^{feet}_{US\text{-}HKC}$								
Constant	-1.174	(11.249)	-25.061*	(13.859)	-7.937	(11.762)	-26.029**	(10.290)
Q_{US}	31.414**	(15.569)	54.538**	(18.180)	35.414**	(15.940)	55.942**	(15.267)
$P^{feet}_{US\text{-}HKC}$	-16.993**	(3.781)	-0.583	(5.925)	-11.140**	(3.791)	---	
P^{feet}_{US}	---		---		---		---	
P^{feet}_{ROW}	1.390*	(0.711)	0.221	(0.816)	0.997**	(0.423)	---	
D1	0.354**	(0.090)	0.341**	(0.098)	0.377**	(0.090)	0.338**	(0.092)
Adj-R^2	0.604		---		0.600		0.598	
Excess Demand: $P^{feet}_{US\text{-}HKC}$								
Constant	0.798**	(0.205)	0.680**	(0.247)	0.783**	(0.210)	0.695*	(0.250)
$Q^{feet}_{US\text{-}HKC}$	-0.020**	(0.003)	-0.018**	(0.006)	-0.020**	(0.003)	-0.017**	(0.006)
$Q^{leg\ qrt}_{US\text{-}HKC}$	-0.007**	(0.002)	-0.007**	(0.002)	-0.007**	(0.002)	-0.007**	(0.002)
P_{HK_live}	-0.004**	(0.001)	-0.004**	(0.001)	-0.004**	(0.001)	-0.004**	(0.001)
GDP_{HK}	1.537**	(0.428)	1.954**	(0.567)	1.634**	(0.442)	1.792**	(0.600)
Q_{Brazil}	-0.001	(0.000)	-0.001	(0.001)	-0.001	(0.000)	-0.001	(0.001)
D1	0.007**	(0.002)	0.007**	(0.003)	0.007**	(0.002)	0.005	(0.003)
Adj-R^2	0.808		---		0.807		0.784	

Table 3. Estimation Results for Chicken Wings Exports to HKC (1997-2000)

Variable	Linear Prices		Relative Prices[a]		Relative Prices[a,b]		No Prices	
Excess Supply: $Q^{wing}_{US\text{-}HKC}$								
Constant	-0.907	(8.219)	N/A[1]		-4.066	(9.778)	-0.264	(6.156)
Q_{US}	7.854	(10.205)	N/A[1]		11.452	(10.729)	7.479	(9.133)
$P^{wing}_{US\text{-}HKC}$	-0.295	(2.265)	N/A[1]		0.193	(3.219)	---	
P^{wing}_{US}	-0.002	(0.029)	N/A[1]		0.010	(0.020)	---	
P^{wing}_{ROW}	0.372	(1.065)	N/A[1]		-0.003	(0.735)	---	
D1	0.156**	(0.057)	N/A[1]		0.144**	(0.057)	0.145**	(0.055)
Adj-$R^{2\,c}$	0.289		---		0.291		0.241	
Excess Demand: $P^{wing}_{US\text{-}HKC}$								
Constant	1.353**	(0.429)	N/A[1]		1.343**	(0.444)	0.896	(0.607)
$Q^{wing}_{US\text{-}HKC}$	-0.068**	(0.013)	N/A[1]		-0.074**	(0.012)	-0.092*	(0.046)
$Q^{leg\ qrt}_{US\text{-}HKC}$	0.023**	(0.003)	N/A[1]		-0.024**	(0.003)	-0.021**	(0.004)
P_{HK_live}	-0.006**	(0.002)	N/A[1]		-0.006**	(0.002)	-0.005	(0.003)
GDP_{HK}	1.858**	(0.865)	N/A[1]		1.869**	(0.907)	3.065**	(1.316)
Q_{Brazil}	-0.002**	(0.001)	N/A[1]		-0.001	(0.001)	-0.001	(0.002)
D1	0.018**	(0.005)	N/A[1]		0.017**	(0.005)	0.018**	(0.007)
Adj-$R^{2\,c}$	0.650		---		0.650		0.621	

[a] P_{US} and P_{ROW} represent US and ROW price relative to US-HKCH own-price, respectively.
[b] Price ratios calculated before estimation, linear estimation used.
*significant at the 10 percent level, ** significant at the 5 percent level.
Numbers in parentheses are standard errors of the estimated parameters.

Table 4. Estimation Results for Chicken Legs Exports to HKC (1997-2000)

Variable	Linear Prices		Relative Prices[a]		Relative Prices[a,b]		No Prices	
Excess Supply: $Q^{leg}_{US\text{-}HKC}$								
Constant	0.817	(4.034)	N/A[1]		-4.945	(4.873)	-11.229**	5.494)
Q_{US}	9.493	(5.659)	N/A[1]		11.433*	(6.296)	23.363**	(8.151)
$P^{leg}_{US\text{-}HKC}$	-9.857**	(1.313)	N/A[1]		-3.060**	(1.046)	---	
P^{leg}_{US}	0.054**	(0.023)	N/A[1]		0.035**	(0.014)	---	
P^{leg}_{ROW}	2.513**	(0.626)	N/A[1]		1.613**	(0.462)	---	
D1	0.082*	(0.042)	N/A[1]		0.086*	(0.043)	0.059	(0.049)
Adj-$R^{2\,c}$	0.450		---		0.430		0.307	
Excess Demand: $P^{let}_{US\text{-}HKC}$								
Constant	0.470	(0.404)	N/A[1]		0.610	(0.444)	0.205	(0.851)
$Q^{leg}_{US\text{-}HKC}$	-0.099**	(0.014)	N/A[1]		-0.096**	(0.013)	-0.092**	(0.032)
$Q^{leg\ qrt}_{US\text{-}HKC}$	-0.012**	(0.003)	N/A[1]		-0.014**	(0.004)	-0.012*	(0.007)
P_{HK_live}	-0.002	(0.002)	N/A[1]		-0.002	(0.002)	-0.001	(0.003)
GDP_{HK}	2.854**	(0.872)	N/A[1]		2.529**	(0.974)	3.321	(1.987)
Q_{Brazil}	0.000	(0.001)	N/A[1]		0.001	(0.001)	0.002	(0.002)
D1	0.003	(0.005)	N/A[1]		0.002	(0.005)	-0.004	(0.007)
Adj-$R^{2\,c}$	0.626		---		0.632		0.603	

Table 5. Estimation Results for Chicken Offal Exports to HKC (1997-2000)

Variable	Linear Prices		Relative Prices[a]		Relative Prices[a,b]		No Prices	
Excess Supply: $Q^{offal}_{US\text{-}HKC}$								
Constant	-24.212**	(10.431)	-28.512**	(11.786)	-28.358**	(9.592)	-34.166**	(9.297)
Q_{US}	32.826**	(14.572)	40.032**	(15.649)	32.227**	(13.607)	52.300**	(13.793)
$P^{offal}_{US\text{-}HKC}$	-1.138	(2.388)	0.566	(3.302)	4.262*	(2.487)	---	
P^{offal}_{US}	---		---		---		---	
P^{offal}_{ROW}	8.866**	(1.927)	3.635**	(1.336)	7.242*	(1.365)	---	
D1	0.749**	(0.088)	0.758**	(0.098)	0.656**	(0.088)	0.913**	(0.083)
Adj-$R^{2\,c}$	0.891		---		0.901		0.868	
Excess Demand: $P^{offal}_{US\text{-}HKC}$								
Constant	1.720**	(0.640)	2.015**	(0.729)	2.122**	(0.587)	2.019**	(0.883)
$Q^{offal}_{US\text{-}HKC}$	0.015	(0.012)	-0.004	(0.023)	0.002	(0.011)	-0.026	(0.033)
$Q^{leg\ qrt}_{US\text{-}HKC}$	-0.028**	(0.004)	-0.025**	(0.004)	-0.028**	(0.004)	-0.022**	(0.004)
P_{HK_live}	0.001	(0.003)	-0.001	(0.004)	-0.002	(0.003)	-0.002	(0.004)
GDP_{HK}	-2.319*	(1.304)	-2.776*	(1.513)	-2.943**	(1.200)	-2.845	(1.823)
Q_{Brazil}	-0.003	(0.002)	-0.003	(0.003)	-0.002	(0.002)	-0.000	(0.004)
D1	-0.011	(0.008)	0.006	(0.012)	-0.006	(0.008)	0.016	(0.017)
Adj-$R^{2\,c}$	0.654		---		0.663		0.482	

[a] P_{US} and P_{ROW} represent US and ROW price relative to US-HKCH own-price, respectively.
[b] Price ratios calculated before estimation, linear estimation used.
*significant at the 10 percent level, ** significant at the 5 percent level.
Numbers in parentheses are standard errors of the estimated parameters.

The excess supply estimation generally yielded significant coefficient estimates for U.S. chicken production (Q_{US}) with the expected positive signs, and with the strongest relationships for chicken feet and chicken offal. This implies that U.S. production played an important role in determining the quantity of these chicken parts supplied to Hong Kong/China, especially for the lower-valued products. The more whole chicken the U.S. produces, the more chicken parts are exported to HKC.

Results for the inverse excess demand equations are generally consistent across specifications. The estimation results indicate that import prices are responsive to the import quantities, except for chicken offal. The coefficients of HKC import quantity are all negative and significantly different from zero at the 5 percent level (except for chicken offal), revealing that lower import prices are associated with higher quantities of U.S. exports. HKC prices of these four chicken parts imports are negatively related to the quantity of HKC chicken leg quarter imports, which is determined by Russia's leg quarter imports from the U.S. This suggests that leg quarter imports diverted from Russia significantly influenced HKC chicken parts import prices.

The Hong Kong GDP coefficient estimates are positive and mostly significantly different from zero at 5 percent level, except for offal. This suggests that HKC consumers demand more U.S. chicken as their income increases. The coefficients for Hong Kong consumer price index for live poultry are mostly negative and significantly different from zero at the 5 percent level for feet and wings. These results do not support the contention that chicken feet and wings are substitute products for live poultry in HKC. We did not find the expected positive relationships between export quantity ($Q^j_{US\text{-}HKC}$) and export price ($P^j_{US\text{-}HKC}$) in excess supply equations. On the contrary, the coefficient estimate of $P^j_{US\text{-}HKC}$ was found negative for chicken feet and chicken legs, with estimates significantly different from zero at the 5 percent level across specifications. The coefficient estimates of export price for chicken wings were not significant at 10 percent level. These unexpected results indicate that U.S.-HKC parts prices did not positively affect the volume of exports. Our estimates indicate either the absence of a significant impact of own-price on U.S. supply, or a negative impact, depending on the part and the specification.

The U.S. parts price was only available for wings and legs, and was hypothesized to have a negative impact on ES to HKC. The only significant coefficients for Pus were for specifications 1 and 3 for the legs equation, and the sign of these coefficients were different from what was expected. The estimates of P^j_{ROW} were significant and positive for chicken offal, legs and feet, contrary to our expectations. In this study, P^j_{ROW} was assumed to be exogenous, and to affect the U.S. export quantity to HKC. However, this strong positive relationship may be explained by the dominance of HKC in the export market for these chicken parts (especially for chicken offal and feet). A higher ROW price may be caused by increasing the supply to the HKC market. As more exports go to HKC market, less supplies will be sent to ROW, thus the prices in ROW markets will be forced to be higher.

The coefficient estimates of Hong Kong live poultry price (P_{HK_live}) appeared with significant negative signs only for some specifications of chicken feet and wings. This result suggests live HKC poultry may not be a substitute product for frozen U.S. chicken parts. Negative and significant relationship between HKC import chicken part prices and Brazil exports was only found in the case of chicken wings. This implies that when Brazil increases its worldwide chicken exports, the price of U.S. chicken wing exports to HKC will most likely decrease. It can be explained by that Brazil is a major supplier of chicken wings, and a major competitor of U.S. chicken wings exports.

As expected, the adjustment term, D1, was important in explaining the changes in the dependent variables, because most of the equations yielded significant estimates for the variable, D1 at the 5 percent level, especially in the ES equations. The significance shown in ES equations suggests that the substantial decreases in "other" chicken exports in 2000 were accompanied by significant increases in the specified parts exports. This may be due to changes in export reporting or classification in 2000. The lower price response to D1 in ED equations suggests that the export prices were less affected by the shift in 2000.

Finally, excess supply estimation results for chicken wings are rather poor, compared with results for the other three chicken parts. None of the estimates for the explanatory variables in the ES equation are significant at the 10 percent level, except for the adjustment term. Canada is the second largest import

market for U.S. frozen chicken wings, and the largest export market for fresh/chilled chicken wings. Canada's imports may affect the price and amount of chicken wings going to China market. Because we do not have the monthly data of U.S. chicken wings exports to Canada, we may miss some information which is important to explain the quantity of U.S. frozen chicken wings exported to HKC.

Elasticity Estimates

One elasticity was calculated from the supply equation – the elasticity of export quantity with respect to U.S. whole chicken production. From the excess demand equation, we calculated the elasticities of export price with respect to own quantity, HKC chicken leg quarter imports, and Hong Kong GDP. The estimated elasticities for each chicken part and specification presented in Tables 6 - 9. Elasticities were not reported where the coefficient is not significantly different from zero at the10 percent level.

Overall, the calculated excess demand elasticities are consistent across specifications. As to the excess supply elasticity, the calculated elasticities of U.S. chicken part export quantity to US production showed some slight variations. The calculated elasticities for feet vary from 1.680 in specification 1 to 2.965 in specification 4. The calculated elasticity for offal vary from 6.510 in specification 3 to 10.565 in specification 4, and those for chicken legs are 1.629 in specification 3 and 3.318 in specification 4.

The price flexibility coefficients were only calculated for chicken feet, legs, and wings. The magnitude of all the calculated price flexibilities were less than 1, with the price flexibility ranging from -0.423 to -0.497 for chicken feet , -0.456 to -0.616 for chicken wings, and -0.618 to -0.665 or chicken legs.

The calculated price flexibility of chicken part import price to HKC chicken leg quarter imports had negative signs for all the four chicken parts, and are all less than unity. The calculated flexibilities are -0.073 for chicken feet, from -0.146 to 0.159 for chicken wings, from -0.09 to -0.104 for chicken legs, and from -0.186 to –0.202 for chicken offal.

Except for chicken offal, the estimated flexibilities of import price with respect to Hong Kong GDP are all positive. The estimated price flexibilities vary from 0.952 to 1.210 for chicken feet, from 0.770 to 1.269 for chicken wings, and from 1.128 to 1.272 for chicken legs. With the values around unity, it implies that prices were somewhat responsive to changes in GDP growth. In general, the price

responsiveness is more flexible for legs than those for feet and wings. Negative price flexibilities to Hong Kong GDP were found for chicken offal, and the magnitudes are greater than unity.

Table 6. Estimated Elasticities for Chicken Feet Excess Supply and Demand

Elasticity	Linear Prices	Relative Prices[a] (i3sls)	Relative Prices[a] (3sls)[b]	No Prices
Excess Supply: $Q^{feet}_{US\text{-}HKCH}$				
Q_{US}	1.680	2.891	1.877	2.965
Excess Demand: $P^{feet}_{US\text{-}HKCH}$				
$Q^{feet}_{US\text{-}HKC}$	-0.497	-0.448	-0.497	-0.423
$Q^{leg\ qtr}_{US\text{-}HKC}$	-0.073	-0.073	-0.073	-0.073
GDP_{HK}	0.952	1.210	1.011	1.109

Table 7. Estimated Elasticities for Chicken Wings Excess Supply and Demand

Elasticity	Linear Prices	Relative Prices[a] (i3sls)	Relative Prices[a] (3sls)[b]	No Prices
Excess Supply: $Q^{wing}_{US\text{-}HKCH}$				
Q_{US}	N/A[2]	N/A[1]	N/A[2]	N/A[2]
Excess Demand: $P^{wing}_{US\text{-}HKCH}$				
$Q^{wing}_{US\text{-}HKC}$	-0.456	N/A[1]	-0.496	-0.616
$Q^{leg\ qtr}_{US\text{-}HKC}$	0.159	N/A[1]	-0.166	-0.146
GDP_{HK}	0.770	N/A[1]	0.774	1.269

Table 8. Estimated Elasticities for Chicken Legs Excess Supply and Demand

Elasticity	Linear Prices	Relative Prices[a] (i3sls)	Relative Prices[a] (3sls)[b]	No Prices
Excess Supply: $Q^{leg}_{US\text{-}HKCH}$				
Q_{US}	N/A[2]	N/A[1]	1.629	3.318
Excess Demand: $P^{leg}_{US\text{-}HKCH}$				
$Q^{leg}_{US\text{-}HKC}$	-0.665	N/A[1]	-0.645	-0.618
$Q^{leg\ qtr}_{US\text{-}HKC}$	-0.090	N/A[1]	-0.104	-0.090
GDP_{HK}	1.272	N/A[1]	1.128	

Table 9. Estimated Elasticities for Chicken Offal Excess Supply and Demand

Elasticity	Linear Prices	Relative Prices[a] (i3sls)	Relative Prices[a] (3sls)[b]	No Prices
Excess Supply: $Q^{offal}_{US\text{-}HKCH}$				
Q_{US}	6.620	8.086	6.510	10.565
Excess Demand: $P^{offal}_{US\text{-}HKCH}$				
$Q^{offal}_{US\text{-}HKC}$	N/A[2]	N/A[2]	N/A[2]	N/A[2]
$Q^{leg\ qtr}_{US\text{-}HKC}$	-0.202	-0.181	-0.202	-0.159
GDP_{HK}	-1.002	-1.199	-1.271	N/A[2]

[a] P_{US} and P_{ROW} represent US and ROW price relative to US-HKCH own-price, respectively.
[b] Price ratios calculated before estimation, linear estimation used.
[1]: Coefficient estimation didn't converge.
[2]: Coefficient estimate is not significant at the 10 percent level.

Conclusions

Overall, the quantities of U.S. chicken parts exported to HKC are positively impacted by U.S. whole birds production. Coefficients of own price and alternative market price variables were generally either insignificant or significant but with a sign contradicting *a priori* expectations based on theory. Additional work on ES estimation is needed, but these results may support the view that U.S. producers treat these chicken parts as by-products of U.S. chicken production and the HKC market for these chicken parts as a residual market.

With the exception of offal, the demand for U.S. chicken parts in the HKC market should continue to grow as HKC consumers' income increases. Combined with limited domestic chicken production in the HKC market, low per capita poultry consumption, and expected growing income, HKC consumer demand for chicken product will outgrow their domestic production, and their consumption of U.S. chicken products may go up significantly.

China market can absorb more chicken feet and offal without lowing prices much. In the other words, increasing U.S. chicken feet and offal exports to the HKC market would not cause its own export price to decrease significantly. U.S. chicken producers may be able to export more chicken feet and offal to HKC market without lowering its own price too much. According to the empirical results obtained from this study, a 1 percent increase in HKC import quantity of U.S. chicken feet would only cause a decrease on its own import price ranging from 0.423 percent to 0.497 percent.

The HKC chicken leg import price was more responsive to its own import quantity than the other parts examined here. Even for legs, however, a 1 percent increase in exports is accompanied with a decrease in price between 0.618 percent and 0.665 percent. This suggests the export revenues from legs would continue to increase with greater quantities of exports, but the HKC market may be less able to absorb increases in leg shipments than increases of shipments of feet and offal.

Brazil's worldwide chicken exports did not seem to significantly affect the price of U.S. chicken parts exported to HKC, except for chicken wings. However, with Brazil's increasing market share in HKC market, U.S. chicken export prices may eventually be negatively impacted.

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