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Effects of Rising Feed and Labor Costs on China's Chicken Price[1]

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Abstract

China's poultry production and consumption are growing rapidly, but rising input costs could slow its development. Increases in corn and soybean prices and wages are partially transmitted to rising retail chicken prices in China. Corn and soybean meal appear to be substitutes, and corn prices have a stronger impact on chicken prices than does the price of soybean meal. Modest technical change impacts partly offset the effect of rising input prices. Rising grain prices and wages, reinforced by Chinese currency appreciation, are eroding the international competitiveness of the Chinese poultry industry.

Keywords: poultry, chicken, feed, price, import, export, production costs

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[1] The views expressed here are those of the authors and do not necessarily reflect those of the U.S. Department of Agriculture.

Introduction

China is already the second-leading producer of poultry and is viewed as having great potential for further growth (Davis et al. 2013; Pan 2013). As an efficient means of converting feed resources to animal protein, poultry is ideally suited to China's land-scarce production environment.[2] Commercialized poultry production in China played an important role in boosting the country's production and consumption of meat. Output grew nearly ten-fold during 1984-2014, and poultry's share of meat output doubled from 10% to 20% over that period. The recruitment of small-scale farmers to raise chickens contributed to growth in rural income (Ke and Han 2007).

China's poultry also plays an important role in foreign trade. China imports significant volumes of poultry—mostly paws and wings—but it also exports to neighboring Asian countries. Poultry consumes a disproportionately large share of commercial feed manufactured in China—a reflection of the key role of feed companies in developing the industry there. With a relatively high proportion of soybean meal used in broiler feed, the poultry sector's development also played an important role in driving China's surging demand for imported soybeans. China now accounts for about two-thirds of global soybean import demand and USDA projections anticipate that imports of soybeans and corn will continue to grow (Hansen and Gale 2014).

The industry's growth in earlier decades was propelled by low feed costs, liberalization of soybean imports, and rural underemployment, but growth is now constrained by high feed prices and wages (Ke and Han 2007; Pan 2013). Feed prices have been rising in China due to both rapid increase in demand for feed grains and a price support policy that raised grain prices each year in order to boost rural incomes and strengthen production incentives (Gale 2013). At the same time, labor is becoming more costly as rural residents take up nonfarm employment and wages rise. Pan (2013) noted that the country has become a net importer of poultry and some Chinese exporters have shifted sales to the domestic market. Imports have been volatile, while exports have fallen since the early 2000s (Figure 1). Costs were also a central factor in China's imposition of antidumping and countervailing duties on U.S. poultry imports, based partly on complaints that the U.S. industry benefits from lower feed costs.

This research provides insight about how scarcity of labor and feed inputs may influence the future of the industry. We investigate the role of rising input costs on poultry by analyzing prices of chicken, corn, soybean meal and wages in China during 2000-2014. Rising wages increase the opportunity cost of family labor used to raise chickens and make it more costly to hire workers.

In the next section, we describe our data and recent trends in China's chicken and feed prices and wages. We discuss our empirical model that relates marginal costs to prices of feed inputs and labor and report statistical estimates. The results are used to calculate impacts of feed-price and wage increases on chicken prices. We then discuss the implications for China's poultry industry and foreign trade.

[2] Feed-conversion ratios in China are approximately 2:1 for poultry and 3-to-4:1 for swine—the dominant type of livestock.

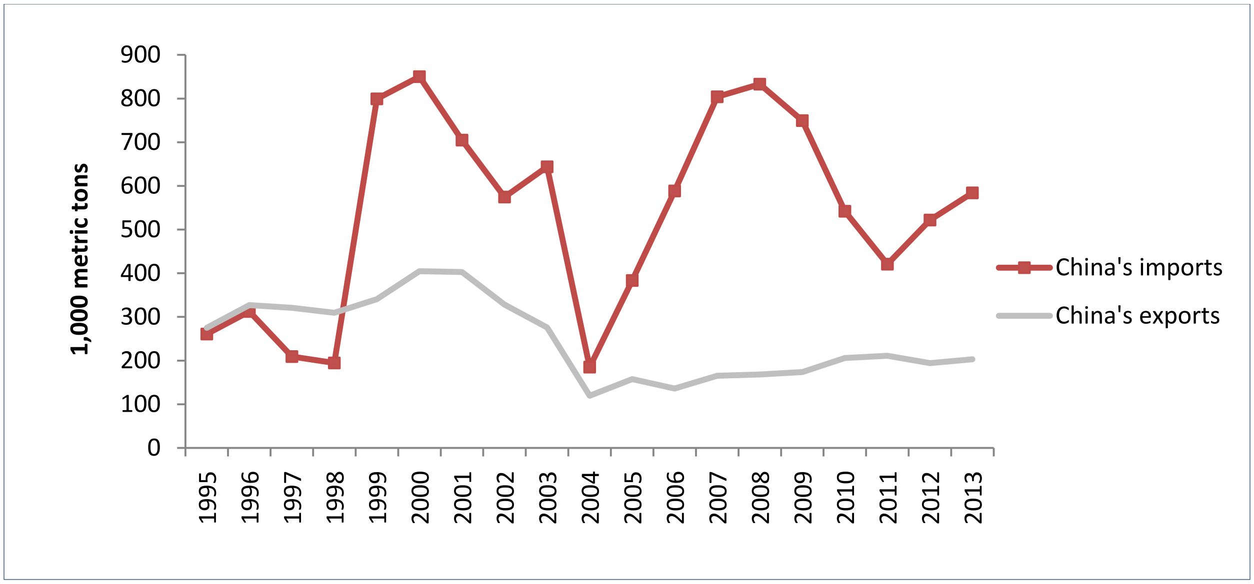

Figure 1. China's Trade in Poultry Meat 1995-2013

Note. Data for HS 0207, meat and edible offal of poultry.
Source. Analysis of China customs data reported by Global Trade Atlas.

Data and Trends

China National Development and Reform Commission (CNDRC) production cost survey data show that feed is the most important cost component for Chinese poultry producers. The feed share of unit costs varied between 70 and 74 percent of poultry production costs during 2006-13. Labor is the second-largest cost component, with a share the varied between 11 and 15 percent of cost. The labor predominantly represents imputed opportunity costs of family labor, but larger vertically integrated operations with hired workers are becoming more common (Pan 2013). Feed and labor together account for about 85 percent of production cost. It is also clear that feed costs accounted for most of the increase in unit costs of poultry from 2006 to 2013.[3]

Corn and soybean meal are the two chief ingredients in chicken feed. Li (2010) reports feed recommendations that include 50%-70% corn and 10%-30% soybean meal. Other ingredients like wheat, broken rice, bran and other oilseed meals are used where they are available or during periods of high corn prices. We did not have a long time series of prices for these other ingredients and their proportions in poultry feed are much smaller, so this analysis focuses on prices of corn and soybean meal as the two main feed ingredients.

We compiled monthly data on Chinese prices of chicken, corn and soybeans from January 2000 through May of 2014. The retail price of chicken was reported by China National Bureau of

[3] Another important component of broiler cost was purchase of chicks which also require feed as a major input.

Statistics (2009-2014).[4] For earlier years, we used the retail price reported by China's Price Bureau. These are national averages calculated by authorities based on monitoring of retail and wholesale markets and supermarkets.

Soybean meal and corn wholesale prices were obtained from the China National Grain and Oils Information Center. The corn price is from Shandong, the leading chicken-producing province. The soybean meal price is from Jiangsu, a leading province in both poultry and processing of soybeans into meal and oil. Monthly averages were calculated from daily prices reported by the Center.

China has not consistently reported rural wage data over the period of our study. We compiled an annual rural wage series from three different surveys of rural non-farm wages available for different years to represent the opportunity cost of engaging in poultry production (most labor is supplied by farm family members). For years 2008-13, we used average earnings per day reported by annual national surveys of rural residents' nonfarm employment (For example, China National Bureau of Statistics 2013). That survey was not conducted before 2008, so we obtained average rural nonfarm wages from a Ministry of Agriculture (2010) survey of villages for 2004-2007. No direct wage surveys were available for 2000-04, so we used an average daily wage from poultry cost of production data reported by the China National Development and Reform Commission (CNDRC).[5] We formed an annual series for 2000-13 from these three sources and then interpolated the annual data to form a monthly series. There was no wage estimate for 2014, so we extrapolated the series trend to impute wages for 2014.[6]

The data show a general rise in chicken prices and output of chicken. Official estimates from China's National Bureau of Statistics indicate China's production of poultry rose 50 percent from 2000 to 2013. Overall, the chicken price roughly doubled from RMB 9-10 per kg to RMB 19-20 per kg during 2000-2014 (Figure 2).[7] However, the increase was not at a steady rate. Chicken prices rose in spurts during 2004-05, 2007-08, and 2010-11, interspersed with periods of stagnant or declining prices.

Prices of corn and soybean meal both generally rose over time. The corn price rose about 2.5-fold at a relatively steady pace. Soybean meal prices fluctuated more than corn prices, reflecting fluctuations in global soybean prices. Chinese officials kept corn prices relatively stable using a combination of support prices, buffer stocks, a tariff rate quota on imports and an export tax on grains during the 2007-08 grain price crisis. The fluctuation in soybean meal versus corn prices raises the question of whether feed mills and livestock producers vary the proportion of the two ingredients in response to price changes.

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[4] We also assessed wholesale chicken prices from China Ministry of Agriculture which are slightly lower than the retail price and display similar fluctuations. The wholesale price includes several episodes of sharp decline during avian influenza outbreaks which are not as prominent in the retail data.

[5] The production cost estimates were available for the entire period, but they are not direct estimates of wages. We used other surveys when available.

[6] The annual wages followed a relatively smooth time trend, so it seemed appropriate to impute monthly values using these methods.

[7] We did not deflate prices since accuracy of China's CPI is often questioned and fluctuations in meat prices are one of the important drivers of changes in the CPI. Chicken and pork prices followed similar trends (Pan 2013).

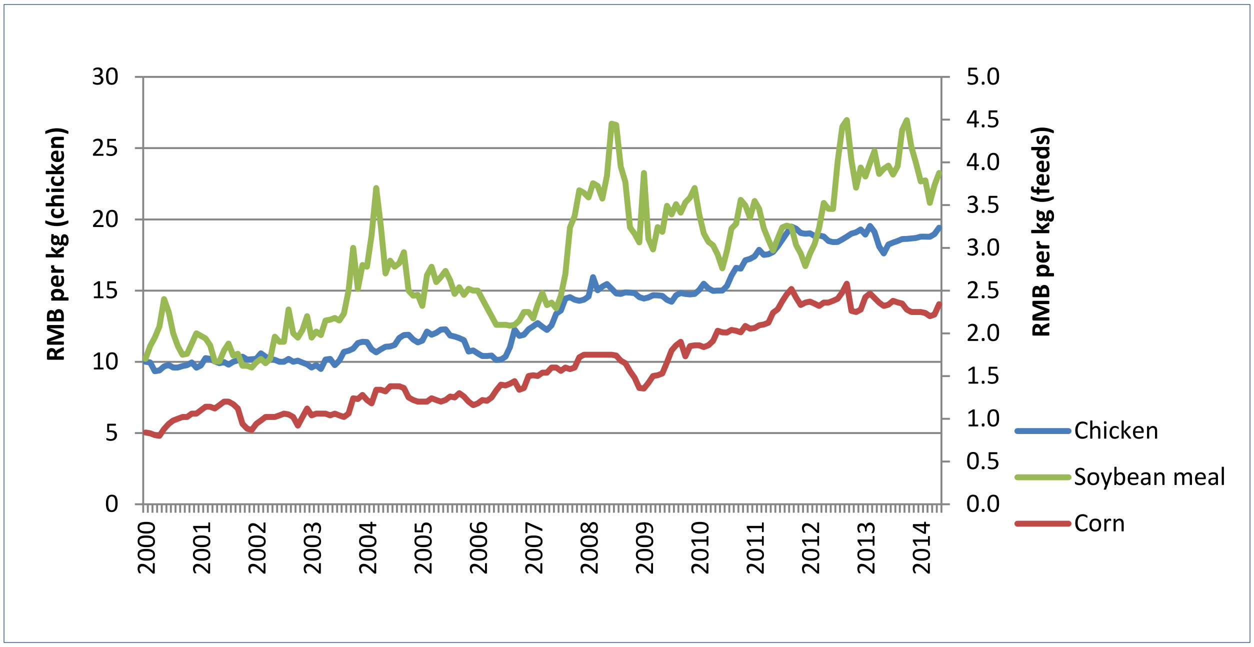

Figure 2. China Chicken and Feed Ingredients Prices 2000-2014

Note. Data are monthly. Chicken price is retail; corn and soybean meal prices are wholesale.
Source. Analysis of data from China National Bureau of Statistics and China National Grain and Oils Information Center.

The wage data indicate that cost of labor has risen dramatically. Rural wages rose three-fold, from about RMB 34-35 per day in 2000-03 to over RMB 100 in 2013. Growth accelerated to 20 percent annually during 2010 and 2011 and remained robust at 12-14 percent during 2012 and 2013. The rise in wages was faster than growth in feed or chicken prices.

Pan (2013) observed that the relatively rapid growth of input prices compared with chicken prices reduced profit margins in the industry. The industry's 50-percent growth in poultry output with a relatively modest increase in chicken price suggests improvements in productivity occurred. In particular, the rising expense of labor suggests strong pressure to increase labor productivity, probably reflected in larger scale of farms.

Empirical Model

The empirical model is based on the standard economic proposition that output price equals marginal cost in a competitive industry. With millions of growers, thousands of processing enterprises, and no significant government intervention in poultry markets, the atomistic structure China's poultry industry is consistent with assumptions of perfect competition. Changes in input prices are reflected in changes in the price of output. The effect on output price of a change in a single input price can be mitigated if inputs are substitutable. Technical change can reduce costs by raising the productivity of inputs.

A standard price/marginal cost markup equation is specified that allows for the possibility of a mark-up over marginal cost (see Lopez 1984; Arnade, Munisamy, and Pick 1998):

$$(1) \quad P = MC(Q, w, T) + K$$

Where P is output price, Q is output quantity, w is input prices, T is a time trend representing technical change, and K is price-marginal cost mark-up (K=0 implies a competitive market while K>0 suggests oligopoly power). This study focuses on assessing the role of input prices in shifting the cost function.

We used a Generalized Leontief functional form with three inputs—corn, soybean meal, and labor—and a time trend that allows for technical change (see appendix):

$$(2) \quad P = \beta_{11}w_1 + \beta_{22}w_2 + \beta_{33}w_3 + \beta_{12}w_1^{\frac{1}{2}}w_2^{\frac{1}{2}} + A_1w_1T + A_2w_2T + A_3w_3T + (\theta_1w_1Q + \theta_2w_2Q + \theta_3w_3Q) + K$$

Where P is the price of chicken, w_i is price of input i, T refers to technology and Q represents the quantity of chicken produced. K=0 if the market is competitive. The function's interaction between corn and soybean prices allows for substitution or complementarity between the two feed inputs. The equation does not include interactions between wage and corn or soybean meal prices, reflecting an assumption that feed inputs and labor inputs are not substitutable.
The effect of the corn price on the chicken price is:

$$(3) \quad \frac{\partial P}{\partial w_1} = \beta_{11} + \frac{\beta_{12}}{2}\left(\frac{w_2}{w_1}\right)^{1/2} + A_1T + \theta_1Q$$

The effect equals a constant, β_{11}, plus a term that includes the ratio of soybean and corn prices, a trend term that represents technical change and a term that depends on output. The effect of soybean meal price on corn price is analogous. The effect of the wage excludes the input price ratio term.

Dickey-Fuller tests revealed that the data was not stationary, but further testing indicated that the data were stationary around a trend. Inclusion of a time trend in the marginal cost function addresses concerns about the properties of models with nonstationary data in addition to capturing effects of technical change.

Results

Table 1 reports the estimated parameters of the price markup equation obtained from 159 monthly observations. The R^2 of 0.97 indicates that the equation has significant explanatory power. In an initial estimate, the Durbin-Watson statistic of 0.557 indicated positive serial correlation of the error term, which is not surprising given our use of monthly data. Serial correlation affects standard errors, but coefficient estimates remain unbiased. We corrected for serial correlation by including a lagged error term in the model.[8] The coefficient of the lagged error (0.79) is an estimate of serial correlation in the error term. After this correction, the Durbin Watson equal to 2.02, indicating that we had removed serial correlation from the model.

Table 1. Estimated Marginal Cost Equation for Price of Chicken

Variable	Estimate	T-Stat
Price Corn	-0.58	-0.40
Price Soymeal	-20.96	-3.78
Wage	0.75	2.65
$PC^{1/2}*PS^{1/2}$	4.98	1.88
T*PC	-0.0002	-0.06
T*PS	-0.04	-3.37
T*Wage	0.001	1.74
Q*PC	-0.03	-0.06
Q*PS	2.32	4.03
Q*Wage	-0.09	-2.47
Q*T	0.007	6.09
K	-1.54	-0.71

Note. Q represents the Quantity of poultry, K is a constant, and T is a time trend that serves as a proxy for technology. Note own price interaction terms $0.5*(w_j^{1/2}w_i^{1/2}) + 0.5*(w_i^{1/2}w_j^{1/2}) = w_i$ when j=i. This provides first three variables reported in the equation above.

T-values indicate that many of the individual estimated parameters are significantly different from zero at the .05 level. We performed F-tests to assess the role of input prices, the time trend, and output quantity in the marginal cost equation. The overall F-statistic for the model was 275, far exceeding the critical value and indicating again that the model as a whole has significant explanatory power. We performed an F-test for each individual variable by restricting all coefficients involving that variable to equal zero and computing the associated F-statistic. These F-tests rejected the hypotheses that corn price, soybean meal price, trend, and quantity could be individually excluded from the model at conventional levels of significance. The F-test for the wage could be rejected only at a p-value of 0.12.

Individual coefficients are difficult to interpret, but some insight can be obtained from the individual estimates. The constant, K, is not significantly different from zero, confirming that the market is competitive. Increases in the wage appear to lead to increase in the chicken price. The effects of corn and soybean meal prices are not easily discerned since the two prices have an interaction term. The positive coefficient on the interaction of corn and soybean meal prices indicates that β_{12} is positive—although it is not individually significant—suggesting that corn and soybean meal may be substitutes. The difference in fluctuation between soybean and corn prices observed in Figure 2 indicated that their relative prices fluctuate, giving feed mills and

[8] It can be shown that this method is equivalent to the common practice of transforming the data using 1-ρ.

livestock producers strong incentive to vary proportions of corn and soybean meal in feed rations.

Impacts on Chicken Price

We used the parameters of the estimated marginal cost function to simulate the effect of input price changes on the retail price of chicken in China. We varied the prices of corn, soybean meal and wages up and down by 10%, 33%, and 50% and computed the impact on the chicken price predicted by the marginal cost function (table 2). These price changes are consistent with recent price changes. Six-month changes in corn and soybean meal prices during the study period were mostly in the range of 20% to -20% with occasional increases of 30% to 50%. As noted earlier, rural wages rose 10% to 20% in several recent years. We also computed the effects of technical change reflected by the time trend.

Table 2. The change in the retail price of chicken in response to a change in input prices—predicted percent change in chicken price

Change in independent variable	Prices of corn and soybean meal both change	Wage	Price of corn	Price of soybean meal	Technology	All explanatory variables
+50%	21.9	15.8	11.3	-5.0	-12.1	9.9
+33%	14.4	10.0	8.1	-1.8	-7.9	10.5
+10%	4.4	3.2	3.4	.2	-2.4	4.4
-10%	-4.4	-3.2	-4.2	-1.0	2.4	-5.7
-33%	-14.4	-10.0	-17.6	-6.9	-7.9	-23.8
-50%	-21.9	-15.8	-32.2	-16.0	-12.1	-41.4

Note. Explanatory variable(s) changed. Table shows predicted effect on retail chicken price from change in explanatory variables shown in table 1.

Noting that corn and soybean meal prices have both been on a rising trend, we computed the predicted effect of simultaneous changes in prices of both corn and soybean meal to characterize the effect of general increases in feed costs. Increases in both corn and soybean meal prices together display the expected relationship—rising feed costs raise chicken prices. However, less than half the increase in feed costs is passed on to chicken prices. A 10% increase in corn and soybean meal prices is associated with a 4.4% increase in chicken price, and a 50% increase in corn and soymeal prices is associated with a 21.9% increase in chicken price. The implied elasticity of chicken price changes in response to joint increases in corn and soybean meal prices is approximately 0.4. Decreases in both feed ingredient prices have symmetric effects on lowering the chicken price.

Increases in the wage are also associated with higher chicken prices. The magnitude of the relationship is slightly weaker than that of corn/soymeal prices. A chicken price-wage elasticity of about 0.3 is implied. Technical change—holding feed prices and wages constant—tends to reduce chicken prices. The magnitude is modest, ranging from -2.4% change in chicken price for a 10% improvement in technology to -12% from a 50% improvement. These estimates are consistent with the discussion of trends that showed chicken prices rose nearly two-fold during 2000-14 while feed prices increased more than two-fold and wages rose three-fold.

The effects of individual changes in corn price and soybean meal price are more complex because the marginal cost equation included an interaction between these two prices. The positive estimate of β_{12} implies substitution is possible between the two ingredients. Thus, the effect of increases in the corn price on the chicken price could be partly mitigated by substituting soybean meal for corn.

A 10% increase in the corn price by itself—holding the soybean meal price and all other variables constant—is associated with a 3.4% increase in the chicken price. A 50% increase in corn price is associated with an 11.3% increase in chicken prices. These effects imply a declining elasticity from 0.3 to 0.2 as the magnitude of the corn price change grows.

The simulated effect of individual increases in the soybean meal price is essentially inconsequential. This reflects the offsetting signs on the estimates of β_{22} and β_{12}. These results are consistent with historic patterns in Figure 2—there were a number of instances where soybean meal prices rose sharply but chicken prices were stable or declining. The weaker effect of soybean meal could reflect its smaller proportion of feed compared with corn and greater flexibility in soybean meal use. Producers and/or feed mills in China may reduce inclusion of soybean meal during periods of high prices.

The effects of corn and soybean meal price changes are asymmetric. Decreases in each commodity's price are associated with a stronger decrease in chicken prices than are increases in those prices. A 10% decrease in the price of corn leads to a 4% decrease in chicken price. A 50% decrease in corn price leads to a 32% decrease in chicken price. These effects imply a corn-chicken price elasticity of 0.4 to 0.6. The effects of decreases in soybean meal price are weaker in magnitude, with a 50% decrease in soybean meal price leading to a 16% decrease in chicken price.

Increasing all input prices and allowing for technical change results in modest increases in chicken price. Increasing all variables by 50% increases the chicken price by 10% as the effects of rising input prices are partially—but not entirely—offset by technical change. These effects are consistent with trends observed in Figure 2.

Conclusions

Our analysis of historical prices from 2000-2014 indicates that rising feed prices and wages tend to increase chicken prices in China. However, less than half of the proportional increase in feed ingredient prices is passed on in rises in chicken prices. Thus, rising production costs push China's chicken prices higher and fluctuations in feed ingredient prices tend to have modest impacts on chicken prices.

The cumulative effects of rising Chinese feed prices and wages combined with currency appreciation contribute to rising chicken prices in China that erode the international competitiveness of the country's poultry. The Chinese wholesale chicken price converted to U.S. cents per lb. was approximately 30 percent less than the U.S. price until 2006 (Figure 3). Since then, the rising domestic price in China combined with appreciation of the Chinese currency against the U.S. dollar has moved the China price 15% to 30% higher than the U.S. price since 2010. Higher prices reduce the competitiveness of China's exports and increase China's demand for imports.

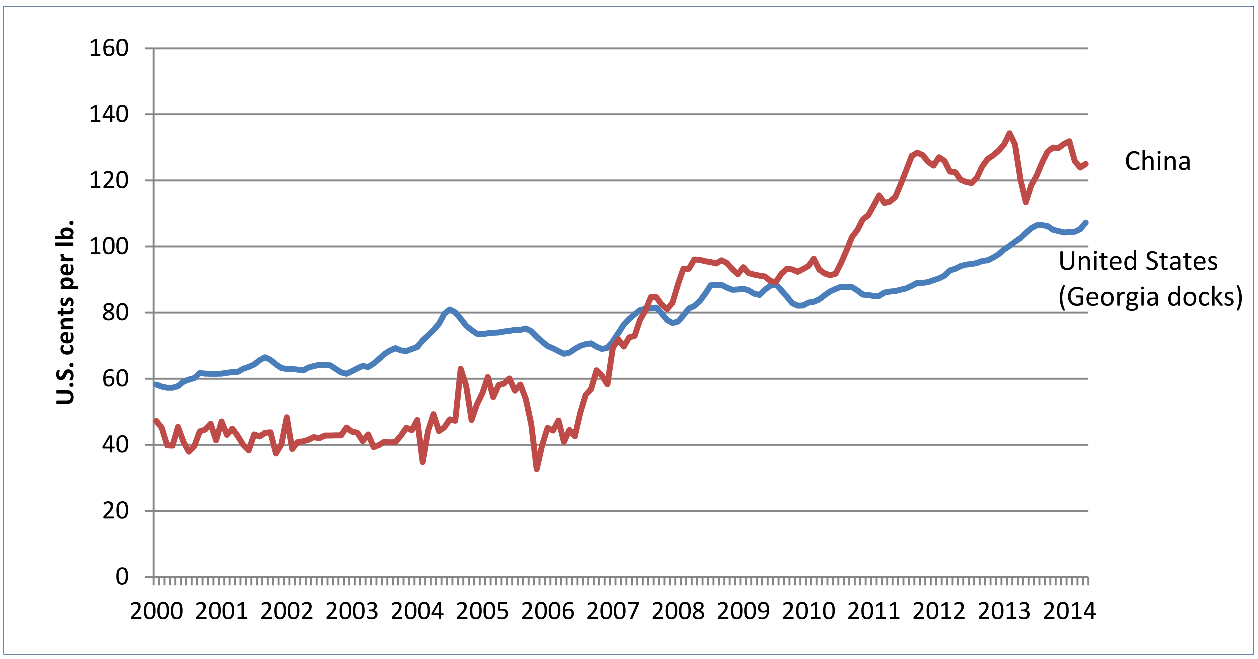

Figure 3. Wholesale Chicken Prices, China and U.S. 2000-2014

Note. China wholesale price converted to U.S. cents per lb using official exchange rate.
Source. Data from China Ministry of Agriculture and USDA, Agricultural Marketing Service.

China's imposition of antidumping and countervailing duties against U.S. chicken beginning in 2010 was based on an assertion that subsidies for crops give U.S. poultry an unfair cost advantage. However, China's relative competitiveness has eroded further since those duties took effect. China's chicken price has moved further above the U.S. price since the duties were imposed. Higher prices for chicken in China may be due partly to that country's policy that raised the floor price for corn each year from 2009 to 2012 (Gale 2013). The relationship between corn and chicken prices suggests that Chinese policies that raised grain prices have contributed to the rise in chicken prices and thus eroded its international competitiveness.

Conversely, China's relatively liberal import policy for soybeans likely benefited its chicken industry by expanding the supply of soybean meal with only modest increases in price. While soybean meal prices have been relatively volatile, that volatility appears to have only a moderate impact on chicken prices. Anecdotal observations indicate that farmers and feed suppliers sometimes substitute cheaper, low-quality, or even counterfeit or adulterated ingredients for soybean meal in feed formulations during periods of high prices. Such changes in feed formulations may mitigate the impacts of feed costs on retail prices to some degree.

Increases in off-farm wages raise the opportunity cost of engaging in poultry production and makes it harder to recruit contract growers. Wages directly affect costs of vertically-integrated production systems that utilize hired labor (Pan 2013). Technical change can mitigate the impacts of rising input prices, but China has already experienced significant technical change by importing breeding stock, subsidizing breeding and propagation farms, and through foreign investment in feed and livestock industries (Ke and Han 2007; Pan 2013).

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Appendix

We specified the cost function using generalized Leontief function form (Diewert and Wales, 1987) which can be written as

$$\text{(A1)} \quad C = \left(\tfrac{1}{2}\right) * \sum_i \sum_j \beta_{ij} w_i^{\frac{1}{2}} w_j^{\frac{1}{2}} Q + \sum_i \beta_i w_i T + \sum_i A_i w_i TQ + \sum_i \alpha_i w_i Q^2$$

Where wi represents the prices our three inputs: labor, corn, and soybeans. T represents technology and Q represents poultry output.

We assume the production technology allows no substitution between labor and feed inputs. That is, producers cannot maintain the same level of output by reducing animal feed and increasing the amount of labor hired. Suppose input 1 is corn, input 2 is soybeans and input 3 is labor. The assumption translates to the restriction $\beta_{13} = \beta_{23} = \beta_{31} = \beta_{32} = 0$, ensuring that, at a given level of output, the demand for corn and soybeans are not influenced by the wage nor vice versa. This is a sufficient condition for ensuring labor and feed do not substitute for each other. We also assume symmetry in cross-price effects: $\beta_{12} = \beta_{21}$.

Prices of corn and soybean meal both generally rose over time. The corn price rose about 2.5-fold at a relatively steady pace. Soybean meal prices fluctuated more than corn prices, reflecting fluctuations in global soybean prices. Chinese officials kept corn prices relatively stable using a combination of support prices, buffer stocks, a tariff rate quota on imports and an export tax on grains during the 2007-08 grain price crisis. The fluctuation in soybean meal versus corn prices raises the question of whether feed mills and livestock producers vary the proportion of the two ingredients in response to price changes. These assumptions reduce the number of parameters, so the cost function can be written as:

$$\text{(A2)} \quad C = Q * (\beta_{11}w_1 + \beta_{22}w_2 + \beta_{33}w_3 + \beta_{12}w_1^{\frac{1}{2}}w_2^{\frac{1}{2}} + A_1w_1T + A_2w_2T + A_3w_3T + \alpha_1w_1Q + \alpha_2w_2Q + \alpha_3w_3Q) + \beta_1w_1 + \beta_2w_2 + \beta_3w_3$$

Taking the derivative with respect to output Q produces the following marginal cost function:

$$\text{(A3)} \quad MC = \beta_{11}w_1 + \beta_{22}w_2 + \beta_{33}w_3 + \beta_{12}w_1^{\frac{1}{2}}w_2^{\frac{1}{2}} + A_1w_1T + A_2w_2T + A_3w_3T + (\theta_1w_1Q + \theta_2w_2Q + \theta_3w_3Q)$$

where the coefficient $\theta_i = 2\alpha_i$ in A3. Equation A3 is substituted into Equation 1 to specify the price mark-up equation 2 shown in the text.

