IFAMR
Special Issue

Factors Influencing Global Poultry Trade

Volume 18 Issue A

The International Food and Agribusiness Management Review
Volume 18 Special Issue A

Factors Affecting Global Poultry Trade

Special Issue Editors

Lead Editor: Christopher G. Davis,
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Economic Research Service

United States Department of Agriculture

International Food and Agribusiness Management Review

The IFAMR (ISSN #: 1559-2448) is published quarterly and is available at http://www.ifama.org. For copyright and publishing information, please contact: Kathryn White, Administrative Editor. IFAMA Business Office • 1010 Vermont Avenue, Suite 201, Washington, DC 20005 • USA • Tel: 1 (202) 429-1610 • Fax: 1 (202) 628.9044 • E-mail: ifamr@ifama.org • Web: http://www.ifama.org

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International Food and Agribusiness Management Review
Volume 18 Issue A, 2015

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Factors Influencing Global Poultry Trade[1]

EDITOR'S INTRODUCTION

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World poultry trade has been on the rise over the last two decades and poultry meat continues to be the top animal protein exchanged globally. In 2000, countries worldwide exported over 8.79 million tons of poultry meat (excluding eggs). Last year (2014), the amount of poultry exported globally almost doubled (94% increase) from the total exported 15 years earlier (GTIS 2015). Shifts in world poultry trade have been influenced by rapid increases in poultry meat exports from Brazil and a sharp decrease in imports by Russia, sporadic outbreaks of avian influenza (AI) worldwide, sanitary regulations, exchange rate volatility, changes in population and income, and consumer preferences.

Recent events demonstrate that poultry trade remains sensitive to such influences. Over the past several months, there have been reported outbreaks of Highly Pathogenic Avian Influenza (HPAI) and Low Pathogenic Avian Influenza (LPAI) in addition to bilateral trade disputes. This has become problematic in many countries, resulting in trade reductions and/or the elimination of trade for major importing and exporting countries.

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[1] The views expressed here are those of the author, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

In response to recent outbreaks of HPAI in poultry flocks in the United States, at least twelve countries (South Korea, China, Qatar, Kuwait, Azerbaijan, South Africa, Morocco, Algeria, Sri Lanka, Indonesia, Ecuador, and Argentina) have suspended imports of U.S. poultry products (FAS/OASA/AD-APHIS). Several other importing countries (39) have placed partial bans on poultry coming from certain counties within specific States. The targeted States include Washington, Oregon, Idaho, Minnesota, Missouri, Arkansas, Kansas, Wisconsin, South Dakota, North Dakota, Iowa, and Montana. Due to avian influenza outbreaks in the U.S., the Hong Kong government is requiring a mandatory health certification for all shell eggs, and other egg product exports, including powdered and liquid eggs (USDA-GAIN Report Hong Kong 2015). This mandate will be enforced starting December 5, 2015. Hong Kong is the third largest egg product market of the U.S. with a 2014 total value of over $52 million.

In mid-October 2014, the World Trade Organization (WTO) ruled against India's ban on U.S. poultry imports, finding the ban inconsistent with its commitments under the WTO sanitary and phytosanitary agreement (National Chicken Council 2014). India imposed the ban in 2007, due to reports of LPAI in U.S. poultry. The mutation of LPAI into a highly pathogenic form of the virus was India's primary concern and reason for the ban. India has since filed an appeal against the WTO's rejection of its ban, citing the same reason initially used when the ban was imposed. Now India is dealing with its own issues of AI outbreaks. India's government informed the World Organization for Animal Health (OIE) of several highly pathogenic avian influenza (HPAI) H5N1 outbreaks on March 18 and 26, 2015 (USDA-GAIN Report India 2015). The areas within India affected by the AI outbreaks include Saari Ka Purwa village, Haliapur village, and Pahadpur Gaderiya Deeh village in Uttar Pradesh as well as Manipur and Andhra Pradesh.

Australia's HPAI outbreak in October of 2013, affecting about 400,000 egg-layer hens, resulted in Hong Kong temporarily banning poultry imports from New South Wales following this outbreak (USDA-GAIN Report Netherlands 2014). Similarly HPAI was found on five poultry farms in the Netherlands in November 2014. Countries that suspended the importation of Dutch poultry include: Hong Kong, South Korea, Ukraine, and South Africa. Estimates of the loss in export meat sales for the Dutch poultry sector range from $100 to 200 million. Like many other countries, Ghana has alerted the OIE of outbreaks of AI (H5 Serotype) in its poultry flocks. The number of cases reported more than doubled after two weeks of Ghana's first OIE reporting on June 2, 2015, despite efforts made to control AI outbreaks within the country. Other African countries, such as Nigeria, Burkina Faso, Niger, and Côte d'Ivoire, have also reported AI outbreaks since December 2014 (Minister of Food and Agriculture, Republic of Ghana 2015).
More recent cases of HPAI have been confirmed in Turkey. Outbreaks were detected in Ikizciler, Kastamonu Province; Edincik, Balikesir Province; and Moralilar, Manisa Province in late April 2015 and on May 11, 2015 (USDA-GAIN Report Turkey 2015). All infected animals within a 3 km radius were destroyed. Protection and surveillance zones have been established 10 km radius surrounding this 3 km radius area. Given the number of outbreaks and continents in which cases have been reported, it is evident that AI is clearly a persistent and dangerous problem for global poultry industries and trade, and HPAI remains a potential threat to human health.

Anti-dumping (AD) disputes also disrupt the flow of poultry trade. For example, China imposed AD duties and countervailing measures on poultry imports from the U.S. in 2009. After a WTO investigation, a decision was given ruling against China stating that these measures were in violation of WTO rules, and duties on China's imports were reduced (Office of the United States Trade Representative 2013).

Approximately 15 years ago, South Africa imposed AD duties on the U.S. that hindered the flow of chicken meat into South Africa. In addition to the U.S., South Africa has also imposed AD duties on frozen chicken imports from Brazil, and on some chicken products from Germany, the Netherlands and the UK. On April 16, 2015, the U.S. Poultry and Egg Export Council (USAPEEC) and South African Poultry Association (SAPA) encourages the negotiation of a tariff-rate quota (TRQ) volume that would take into account the amount of market access U.S. producers previously held in South Africa (Business Day BD Live 2015). However, on June 5, 2015, negotiations between the two governments produced an agreement that will eliminate South African AD duties and allow the U.S. to export 65,000 tons of bone-in chicken to South Africa annually at Pretoria's most-favored nation (MFN) duty of 37%, without AD duties. This agreement also establishes a path toward resolving longstanding spats concerning sanitary and phytosanitary (SPS) measures involving U.S. chicken, beef and pork (Inside U.S. Trade 2015).

Given the large size of poultry trade and the current challenges it faces, the objective of this IFAMR special issue is to examine and discuss how global poultry trade is affected by avian influenza, sanitary restrictions, production efficiency, price and exchange rate volatilities, tariffs and TRQs, and other factors . The special issue features 16 studies that discuss ways economic factors and trade impediments have affected world poultry trade. The studies generally focus on specific factors that have affected poultry trade in particular regions, and the following summary reviews global poultry trade concerns from a regional perspective. The regions explored in this special issue include North America, Asia, Africa, Europe, the Caribbean, and South America.

North America

Zhuang and Moore provide a U.S. perspective on factors influencing poultry exports. The factors that cause the most impediments to U.S. poultry exports are EU technical trade barriers, Indian protectionism using avian influenza as a guise, various anti-dumping cases, Russia's ban in retaliation to U.S. economic sanctions, and religious trade barriers encountered in some Muslim countries. Despite these challenges, Zhuang and Moore postulate that the production efficiency of poultry and increasing income and population in developing countries will produce a positive outlook for U.S. poultry exports over the next decade.

Johnson et al. provide an international perspective on how certain factors contribute to export market recovery after highly pathogenic poultry disease events. Factors that may influence the length of export market recovery include disease type, product type and value, world supply, disease management timelines, disease event size and duration, and country credibility (FAO, 2006). Guidelines established by the World Organization for Animal Health (OIE) suggests that countries previously free of AI can obtain disease free status three months after the last bird affected by AI is culled. However, acquiring this status does not always mean that the export market would recover immediately (Paarlberg 2007; Junker et al. 2009; Hagerman et al. 2012; Philippidis and Hubbard 2005). After a highly pathogenic disease has been discover in a major poultry exporting country and reported by OIE, importers can make three decisions: 1) determine whether to ban imports from a country with an HPAI or Newcastle Disease outbreak, 2) choose whether a trade ban applies to the entire country or a specific geographical area, and 3) decide the amount of time a ban will remain in effect.

Findings show that the duration of the disease event affects the revenue recovery time. Revenue recovery for a poultry exporter is expected to improve more rapidly if its exchange rate falls. Johnson et al. also find that repeated outbreaks of highly pathogenic poultry diseases cause the revenue recovery time to change by a factor of 1.17. Being an agrarian country had an effect on expected recovery time as well. Recovery time for agrarian producers is expected to change by a factor of 0.65.

Ollinger and Taha analyze the economic forces responsible for diminishing levels of *Salmonella* reported in U.S. chicken processing plants. Excessive levels of *Salmonella* have been one of the reasons countries have imposed bans on poultry imports (Mathews et al. 2003). U.S. poultry processing plants uphold a very low or zero tolerance for Salmonella. This is extremely important to several major importing countries because the U.S. is a major exporter of broiler and turkey meat. This article explains how poultry plant size, whether a plant further processed poultry, and lower tolerances for *Salmonella* mandated by Food Safety and Inspection Service (FSIS) resulted in lower levels of *Salmonella* in U.S. poultry. *Salmonella* levels declined from 13 percent of the test sample showing positive *Salmonella* levels in 2006 to only three percent in 2012.

Their findings suggest that, compared to other plants, further processors were about 17 percent more likely to have a food safety performance equal to one-fourth the FSIS *Salmonella* tolerance and 15 percent more likely to have a food safety performance equal to one-sixth the FSIS *Salmonella* tolerance, but further processing was not likely to have one-twelfth the *Salmonella* tolerance level mandated by FSIS. The implication of this study is that low or zero tolerance for *Salmonella* could build poultry exports a strong reputation for food safety, which could enhance poultry exporters' bargaining position.

Price and exchange rate volatilities are two factors that have been known to influence agriculture trade and cause risk-adverse producers to sometime limit product sales to domestic markets. *No et al.* examine pricing-to-market and exchange rate pass-through in the U.S. broiler meat export market using the PTM model as an estimation method. This study fills a research gap by introducing a between panel specification to document the long-run pricing-to-market strategy of U.S. broiler exporters. Previous studies used a fixed specification of panel regression that provided only a short-run pricing behavior in export destination markets.

Findings show that the magnitude of short term transient pricing-to-market is much greater than persistent long run pricing-to-market. These results add further evidence of pricing-to-market behavior in exchange rate pass-through literature. Differences found in this study may be used by policymakers to reduce short run expectations on part of businesses and consumers who will be influenced by exchange rate changes.

Nehring et al. provide insight into what is driving U.S. broiler farm profitability. To examine broiler farm profitability, the authors decompose profitability into four components: net return on assets, asset efficiency, solvency, and net return on equity. One of the important driving factors pointed out is the structure of the broiler industry. The structure of the broiler industry is characterized by high feed efficiency conversion and relatively low production costs per pound of broiler meat. These characteristics have made the U.S. market particularly competitive on a global level.

In addition to acknowledging the importance of technology that improves productivity, this study suggests the main drivers of higher return on equity in U.S. broiler production are farm size, diversification, and housing vintage, where larger, more diversified farms using older housing experienced greater profitability, asset efficiency, solvency, and return on equity. Authors also found that off-farm income was another characteristic of broiler farms and a contributing factor to farm financial performance. The result of high productivity led to greater exports (MacDonald 2008).

Bishop, Jr. et al. shift the focus from national to state in their assessment of Georgia's poultry industry and its impact on the local economy and global trade. Georgia is the largest broiler and poultry producing state with 105 counties that average over $1 million in poultry sales annually. In 2013, the State of Georgia exported almost 539,600 metric tons of broiler chickens valued at $685 million (U.S. Department of Agriculture-FAS 2014). In Georgia's second Congressional District alone, the poultry industry created 10,893 jobs and $2.25 billion in total economic activity in 2011.

Asia

Relevant to the most recent HPAI outbreaks in the U.S., *Davis and Dyck* examine the impacts of AI shocks to a trading system, particularly Korean and Japanese poultry trade. Over the past several decades, avian influenza outbreaks have disrupted the supply of fresh, frozen, and live chicken poultry trade. HPAI outbreaks in China and Thailand have ended the exports of frozen chicken meat from those countries to Japan and Korea; however, cooked meat was still exported. More recently, HPAI outbreaks occurred in the United States and as a result of these outbreaks, Korea banned frozen poultry meat imports from the United States. A Rotterdam model was used to estimate chicken meat trade for 1996-2013 for Japan and 2005-2013 for Korea.

In the Japanese market, the major chicken exporters are the U.S., Brazil, China, and Thailand. Findings suggest that before the restriction (1996-2003), China and Brazil own-price elasticities have the greater impact and more significant role in explaining changes in Japanese imports of chicken meat than do the Thai, U.S., or Rest of the World (ROW) own-prices. However, after the restriction (2004-2013), the U.S. and the ROW own-price elasticities are elastic (1.14 and 1.99, respectively). Given Korea's ban on U.S. frozen poultry meat, findings from this study suggest that Brazil will substitute for Korean imports from the United States. If Brazil were also affected, findings suggest that processed poultry meat imports from Thailand and China would rise.

Already the United States' leading agricultural trading partner, *Marchant and Xie* explore the potential for China to become a larger importer of U.S. poultry meat. The authors examine China's demand, supply, food safety, and trade barriers which affect poultry trade between the two countries. While China is the second largest producer of poultry products, behind the United States (Pi, Zhang and Horowitz, 2014), its demand for poultry meats has grown along with population and income. The authors note that China is not one of the top U.S. poultry export destinations, because it is currently able to produce enough for its own consumers. However, in the long-run, as the poultry sector in China deals with high feed costs, particularly for maize and soybeans coupled with other potential food safety issues, the U.S. poultry industry may benefit from access to world's largest poultry market.

Gale and Arnade elaborate more on the effects of rising feed and labor costs on China's chicken price. Over the past three decades, China poultry production grew about ten-fold. China exported poultry to neighboring Asian countries and imported large quantities of poultry, particularly paws and wings. However, lately growth in poultry production has been constrained due to high feed prices and wages (Ke and Han 2007; Pan 2013). Rising demands for feed grains and unfavorable price support policy coupled with rural residents' pursuit of nonfarm employment have given rise to high chicken prices. The authors' findings suggest that a 10% increase in corn and soybean meal prices will cause domestic chicken prices to increase 4.4%. Their findings also reveal that changes in corn and soybean meal price are asymmetric and that decreases in these two input prices are associated with a stronger change in chicken prices than are increases in those prices.

Hellin et al. analyze the rapid growth of India's poultry industry and discuss potential for global poultry trade. Like the U.S. and Brazil, the majority of India's poultry industry is dominated by large scale vertically coordinated farms. India's rapid growth in poultry production is fueled by scientific advances in poultry breeding and disease control, and the availability of low-priced feed (Ravindran 2013). Over the last ten years, corn availability has increased as corn production in India has grown by 56%. Large corn supplies have contributed to lower-priced poultry meats. The authors pointed out that while India is responsible for less than 0.4% of the world poultry trade, its poultry exports have increased from almost 517,000 tons in 2010-11 to 578,000 tons in 2012-13. Larger poultry farms, competitive prices, and Indian entrepreneurship are factors the authors believe will allow India to take a more active role in the global poultry trade.

Africa

Like some of the previous studies mentioned above, *Taha and Hahn* provide insight into the factors driving poultry and meat imports, but their focus is on South Africa. According to the authors, imported poultry is the fastest growing meat product in South Africa. This study evaluates three crucial factors to determine which variable affects South Africa meat imports the most: 1) changes in consumer taste and/or meat processing technology, 2) poultry and meat prices, or 3) scale or size of the meat import market.

The authors find that changes in taste and technology had a larger impact on South African increased demand for imported poultry and pork than did changes in poultry or pork prices. Unlike previous studies, the authors' estimates show that poultry prices have had small impacts on long-term trends in South African meat imports. Their findings also suggest that poultry is a substitute for pork, sheep/goat, and offal.

Nourou seeks to identify any commonality in the volatility processes of prices for poultry and other agricultural food commodities not only in Cameroon but the world. The motivation for this study was fueled by large changes in food prices occurring after the financial crisis of 2008. This study analyzes the volatility transmission between poultry price and other commodity prices such as beef, fish meal, food and beverage price index, fuel, and a collection of all other commodities. To measure the degree of poultry price volatility, the author used standard dispersion indicators. Specified poultry international price volatility at time "t" was obtained from GARCH-type models.

The findings indicate that poultry prices experienced less volatility over the last several years relative to beef, fish meal, food and beverage price indexes, fuel, and all other commodities. The author also discovered that the transmission of price volatility from other agricultural food commodities to poultry prices is rather weak. One of the implications of this study is that poultry prices are less sensitive to agricultural food commodities' prices and agribusinesses could consider poultry as a relatively safe activity when building their portfolio of activities.

Heise et al. shift the focus and look at the advantages and disadvantages of market entry of foreign companies into Nigeria's poultry industry. Poultry is an important source of animal protein for Nigeria. Import demand for eggs and poultry meat has significantly increased in recent years, and Nigerian poultry production has not kept pace with the rapid increase in domestic consumption. This study looks at expanding Nigeria's poultry industry and the benefits and challenges of doing so. The authors paint a vivid picture of Nigeria's political climate, economy, social cultural, available technology, ecology, and legal factors.

Using a political, economic, social-cultural, technological, ecological, legal (PESTEL) analysis and strengths, weaknesses, opportunities, threats (SWOT) analysis the authors assess the environment and current state of the poultry market in Nigeria and determine the attractiveness of market entry from the perspective of a foreign direct investor. Findings from this study reveal that the PESTEL and SWOT analyses suggest that the market for poultry products in Nigeria cannot be assessed as clearly positive or negative but reveals a mixed picture. Some points that may cause investors to entry Nigeria poultry markets are favorable agricultural policies, strong GDP growth, and growing demand. However, challenges such as poverty, high unemployment, and corruption may cause foreign investors to have second thoughts.

Europe

Like the United States, Europe, particularly Germany, the Netherlands and the United Kingdom have recently reported outbreaks of avian influenza. During HPAI outbreaks from 2005 to 2014, data show that EU-27 imports of uncooked poultry declined while imports of cooked poultry rose. *Taha and Hahn* analyze HPAI impact on EU-27 import demand for cooked and uncooked poultry and other meats. Findings suggest that HPAI outbreaks had statistically significant impacts on EU27 import demand for meats. Cooked poultry imports increased during HPAI outbreaks and imports of uncooked poultry along with beef, pork, and other meats declined. The authors' findings suggest that EU consumers have become quite sensitive to HPAI outbreaks and have developed a strong taste for imported cooked poultry meats. This shift in import demand has become permanent and is statistically significant. According to the authors, EU-27 cooked poultry imports has become largest of all meats imported, accounting for almost half of EU-27 imports during 2012-2014.

The Caribbean

Walters et al. analyze the demand for imported poultry products in the Caribbean Community (CARICOM), and evaluate a modified Common External Tariff (CET) for poultry products from the United States, Brazil, Canada and the European Union. As poultry meat imports continued to grow, government officials and the Caribbean Poultry Association expressed concern and requested stronger support and protection for the domestic poultry industry against lower-priced imported poultry meats (Agritrade 2011, 2012). In attempt to address this issue, the authors evaluated two scenarios: (1) doubling of the CET rate to 80% and (2) complete removal of the CET. The current CET used for imported agricultural commodities by CARICOM member states is 40%.

Findings reveal that own-price elasticities for CARICOM's poultry import demand is highly price responsive in both the short run and the long run. *Walters et al.* also show that both the U.S. and Brazil stand to benefit from poultry import growth into CARICOM during the short- and long-run, if the CET is removed. In the study, the largest benefactor was Brazil whose poultry shipments to CARICOM would increase by approximately 129.5% while the amount shipped from the U.S. would increase by about 100% over current imported quantities. If the CET is doubled in the short-run, import quantities will decrease from all source countries, with the largest reduction in poultry imports from Brazil (85.7%), followed by the U.S. (65.9%), EU (38.3%), and Canada (4.7%). Similarly, in the long–run, poultry imports from Brazil (91%) and U.S. (64%) will decrease while poultry imports from Canada are projected to increase despite the doubling of the CET.

South America

Valdes et al. examine the costs, returns, and profitability of commercial poultry production in Brazil and the influence production efficiency had on poultry trade. Brazil leads the world in broiler meat exports and ranks third in overall poultry production. In 2014, Brazil exported 3.6 million tons of broiler meat, which accounts for 34% of the world's total broiler exports. While a number of studies have analyzed issues related to agricultural productivity improvements for major food crops like rice and wheat (Kamruzzaman et al. 2007; Coelli et al. 2002) only a few have focused on poultry meat farms (Areerat et al. 2012; Begum et al. 2010).

The authors' find that access to credit for poultry production helps increase the ability to use better quality inputs and services. Large flock size significantly reduces inefficiency as it helps derive economies of scale in input purchases and output sales. Findings from the study also reveal that the most integrated operations in the Center West and Southeast regions are the most efficient, with lower per-unit costs. Poultry enterprises in these regions might reap the benefits of an expanded domestic and export demand-led market. These findings are supported by USDA's 2014 Baseline, which expects Brazil's poultry meat exports to represent nearly 41 percent of global poultry trade over the next decade (USDA/OCE/WAOB 2014).

Acknowledgements

I would like to extend a sincere thanks to Dr. Freddie Powell Sims for her teaching, guidance, and influence and to my colleague, John Dyck for his expertise in agricultural trade. Finally, I thank co-editors: Keithly Jones, William Hahn, David Harvey, Carlos Arnade, and Milton Madison for the marvelous work they have done in helping put together a time-relevant body of research that provides insight into the factors influencing today's global poultry trade.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Factors Influencing U.S. Poultry Exports

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Abstract

We investigate major factors behind U.S. poultry exports. While many economic variables such as exchange rate and foreign consumer income and animal disease such as avian influenza affect U.S. poultry exports, trade barriers of various kinds tend to impact U.S. poultry exports more significantly. The major trade barriers facing U.S. poultry exports include EU technical trade barrier, Indian protectionism using avian influenza as a guise, various anti-dumping cases, Russian ban in retaliation to U.S. economic sanctions, and religious trade barriers encountered in some Muslim countries.

Keywords: U.S. poultry exports, trade barriers

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Introduction

Over the past two decades, U.S. poultry exports have grown significantly. From 1994 through 2013, U.S. poultry exports increased at an average annual rate of 5.4 percent, from 1.523 million metric tons to 4.105 million metric tons (Figure 1). During this period, broiler exports grew at an annual rate of 5.5 percent, from 1.307 million metric tons to 3.632 million metric tons, while turkey exports increased from 127,187 metric tons in 1994 to 344,346 metric tons in 2013, an average annual growth rate of 5.4 percent.

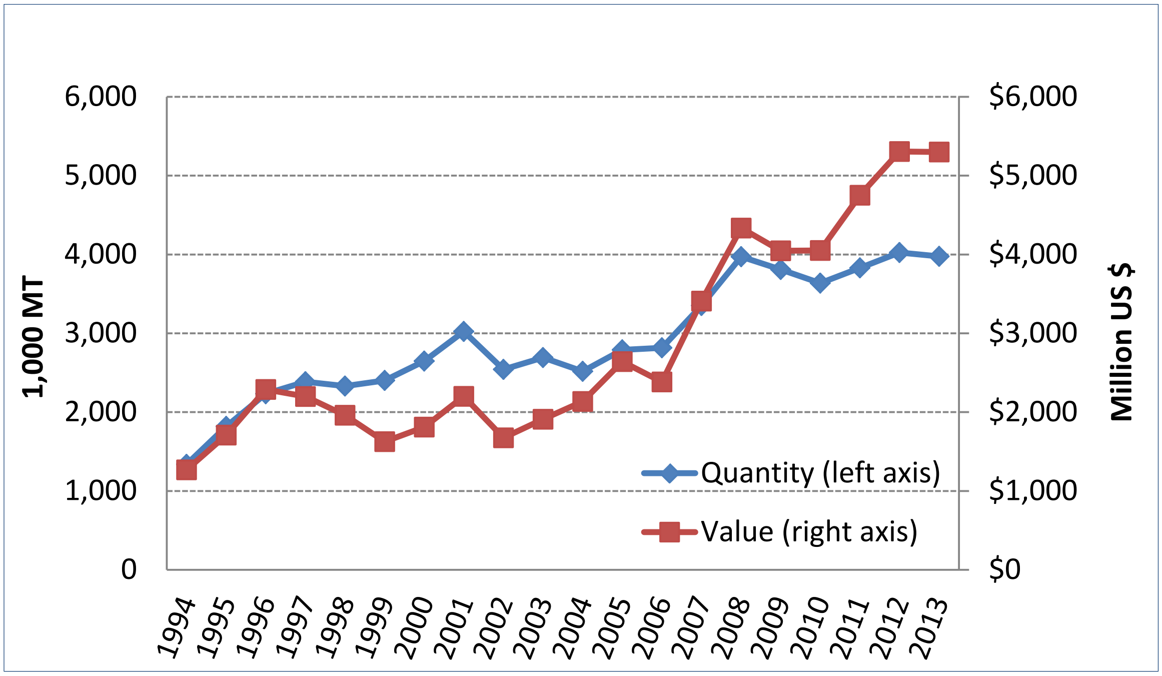

Figure 1. U.S. Poultry Exports in 1994 -2013
Source. USDA Foreign Agricultural Service's Global Agricultural Trade System

During this same period, U.S. broiler production increased at an average annual rate of 2.4 percent, from 10.735 million metric tons in 1994 to 16.976 million tons in 2013, and turkey production grew from 2.239 million tons to 2.623 million tons in 2013, an average annual growth rate of 0.8 percent. As poultry exports have grown at a faster pace than production, the percentage of U.S. poultry production that is exported has risen. For broilers, export share of production (by ready-to-cook weight) increased from 11.8 percent in 1994 to 20.8 percent in 2013, and for turkey the share of production exported rose from 5.7 percent to 13.1 percent.

The importance of exports as a driver of U.S. poultry production is evident, given the fact that, after many years of increase, U.S. poultry consumption has leveled off. Per capita chicken consumption in the U.S. in the past decade ending in 2013 averaged 44.0 kilograms, with a standard deviation of 1.2 kilograms, while U.S. per capita consumption of turkey averaged 7.6 kilograms, with a standard deviation of 0.3 kilograms. As shown in Table 1, the increases in broiler and turkey production from 1994 to 2013 are largely attributable to increased exports.

We expect that exports will account for an increasing share of U.S. chicken and turkey production well into the future.

Table 1. U.S. Broiler and Turkey Production, Consumption and Exports (in 1,000 MT)

	Broiler			Turkey		
Years	Increase in Production	Increase in Consumption	Increase in Exports	Increase in Production	Increase in Consumption	Increase in Exports
1984-1993	4,082	3,380	706	958	853	99
1994-2003	3,961	3,164	928	290	191	92
2004-2013	1,690	599	1,170	182	21	137

Source. USDA Foreign Agricultural Service's Global Agricultural Trade System and PSD database

So far, very few studies in the existing literature have looked at this issue, which is of critical importance for the U.S. poultry industry. The objective of this paper is to examine the major factors behind U.S. poultry exports.

While many economic variables such as currency exchange rates, consumer incomes in importing countries, and foreign poultry production, etc., affect U.S. poultry exports, it is trade barriers that tend to have a more obvious and significant impact. In the 1990s, the primary function of the USA Poultry & Egg Export Council (USAPEEC) was promoting U.S. poultry around the world. Today, although USAPEEC remains a promotional organization, its focus has expanded to include addressing unfair trade restrictions against U.S. poultry around the world. While many of these trade barriers are protectionist in nature, we see a growing number that target U.S. poultry in response to U.S. government policies. The major factors affecting U.S. poultry exports include, but are not limited to, the following:

Technical Trade Barrier Used by EU against U.S. Poultry

The European Union has banned all U.S. poultry imports since 1997 because of the use of chlorine as a post-slaughter pathogen-reduction treatment on raw poultry carcasses. This has effectively denied market access to the entire EU-28 market for U.S. poultry. The use of hyper-chlorinated water as an anti-microbial treatment is the standard practice in the majority of U.S. poultry slaughter establishments, and is considered by U.S. regulators (in particular USDA Food Safety and Inspection Service) to be safe and efficacious.

The European Union is, in theory, a very attractive potential market for U.S. poultry, with a population of more than 520 million consumers, and a relatively high standard of living. We estimate that the EU-28 market for U.S. poultry could approach $600 million annually if the U.S. could gain access. In 2009-2013, EU-28 poultry imports averaged at 608,670 metric tons valued at $2.2 billion in CIF value (see table 2). Assuming the shipping and insurance cost is 20 percent of export value (a conservative assumption), this amounts to over $1.8 billion in FOB value. The U.S. only needs to capture one third of the market share of $1.8 billion to get $600 million.

Table 2. EU-28 Poultry External Imports (Quantity in MT, value in million US$)

	2009	2010	2011	2012	2013
Quantity	639,342	606,098	625,681	626,452	545,778
Value	2,041	2,028	2,390	2,237	2,086

Source. Eurostat (via the Global Trade Atlas)

Unfortunately, during the past 18 years, the U.S. government has been less than successful in having the European Union begin to provide for fair market access for U.S. poultry. Even though the EU Scientific Advisory Committee approved alternative antimicrobials to chlorine as being safe and efficacious in reducing pathogens on raw poultry, the European Food Safety Authority and European Council have completely hindered U.S. poultry efforts to regain market access.

India's Protectionism in Poultry Trade

India is a very protectionist country in terms of poultry trade. For decades, India has denied access to poultry imports from all suppliers, including the U.S. The primary trade barrier that India has employed since 2006 has been its ban on imports from any country that has reported any incident of avian influenza (AI), regardless of pathogenicity. India, meanwhile, has had numerous outbreaks of highly pathogenic avian influenza (HPAI).

Under the guise of protecting its domestic poultry industry from low pathogenic avian influenza (LPAI), India imposed a ban on U.S. poultry imports in 2007 after a finding of LPAI in the United States, but produced no scientific evidence to support the ban's validity. In response, under World Trade Organization (WTO) rules, the Office of the U.S. Trade Representative (USTR) initiated consultations in March 2012, refuting India's claims that LPAI will mutate into a highly pathogenic form of the virus. As the consultations were unsuccessful in resolving the dispute, the U.S. requested the establishment of a panel by the WTO Dispute Settlement Body in May 2012. Not surprisingly, the WTO found that India's AI measures were inconsistent with the relevant articles of the WTO's sanitary and phytosanitary (SPS) agreement. WTO announced its ruling against India in its ban on U.S. poultry products on October 14, 2014. However, the ruling does not give the U.S. automatic access to the Indian market.

The potential market for poultry in India is huge. India has a population of about 1.22 billion in 2013, with Hinduism, the largest religious group in the country, accounting for about 80 percent of the population. Beef and pork are basically avoided by Hindus and Muslims, respectively, for religious reasons (Seetharaman 2013). Per capita poultry consumption in India is currently less than 3.0 kilograms, while India's National Institute of Nutrition recommends a per capita consumption of 10 kilograms. Per capita real GDP in India, which grew at an average annual rate of 6.3 percent in the past decade ending in 2013, is predicted to continue increasing at an average annual rate of 6.1 percent throughout the next decade.

We believe that if India were to open its market and to apply international rules fairly, the United States could compete effectively and successfully in the market. The current India market for poultry is about 3.4 million metric tons annually, with an average annual growth rate of about 8.5 percent in the past decade ending in 2013. Quick-service restaurants and modern supermarkets are rapidly expanding in India, and imported U.S. poultry is an attractive supply option for many of these new food outlets. U.S. poultry exports to India could exceed $300 million annually if India were to open its market.

Anti-Dumping Cases against U.S. Poultry Products

South Africa Anti-Dumping Case

The South African Poultry Association petitioned the government of South Africa to launch an anti-dumping (AD) investigation against U.S. bone-in chicken cuts in November 1999, and the government imposed punitive AD duties a year later retroactive to July 5, 2000, for a period of five years. Every five years since, South Africa has renewed its prohibitive AD duties.

The International Trade Administration Commission of South Africa (ITAC) initiated the first sunset review in September 2005, which the Supreme Court of Appeal of South Africa ruled as invalid, as the date was more than five years after the imposition of the provisional AD duties. However, ITAC simply disregarded it and renewed the AD duties in October 2006 for another five years.

For the second sunset review launched in June 2011, USAPEEC provided a substantial amount of information to ITAC that clearly showed that U.S. chicken products were fairly priced and not dumped in South Africa. However, ITAC extended and even increased the AD duties in April 2012 for another five years.

Not surprisingly, the petitioners have failed to achieve their objective of limiting poultry imports. In fact, chicken imports into South Africa have increased rapidly since the anti-dumping case was initiated. Specifically, South Africa’s chicken imports increased from 63,560 metric tons in 2001 to 354,728 metric tons in 2013, an average annual increase of 15.4 percent, according to South Africa’s official import statistics. The AD case has simply diverted South Africa’s chicken imports from the United States to other exporting countries, particularly Brazil. U.S. share in South Africa chicken imports decreased from 53.9 percent (average in 1996-1999) to 1.3 percent (average in 2001-2013), while Brazilian share increased from 8.2 percent to 65.8 percent (Global Trade Atlas database).

Although the U.S. industry mounted an aggressive (and ultimately unsuccessful) defense, the U.S. government chose not to challenge South Africa on the case in the WTO, which helped fuel three subsequent AD cases against U.S. chicken.

Ukraine Anti-Dumping Case

Ukraine initiated an AD case against imports of both U.S. and Brazilian broiler in March 2009, at the request of three Ukrainian companies. USAPEEC and 17 U.S. companies registered as interested parties in the subsequent investigation. For Brazil, 15 Brazilian companies and the Brazilian Chicken Producers and Exporters Association (ABEF) registered as interested parties.

Because of the large number of registered parties, Ukraine decided to use sampling method in the AD investigation. However, Ukraine provided no sampling results within the specified time-frame. As a result, most companies decided not to answer the lengthy and complicated questionnaire without knowing the sampling results, or chose not to pursue the case further.

USAPEEC fully cooperated throughout the AD investigation process in answering the investigators' questions and requests for information. USAPEEC submitted a commentary on the petition, including a specific data analysis on the case. USAPEEC also submitted a commentary on the petition jointly with ABEF. After a hearing in October 2009, USAPEEC and ABEF submitted a post-hearing brief in November 2009. In July 2010, USAPEEC and U.S. Embassy officials in Kiev, Ukraine, met with relevant Ukrainian officials to urge termination of the AD investigations. The discussions were very productive, and consequently Ukraine took into account USAPEEC's arguments and rescinded the anti-dumping case in October 2010.

Chinese Anti-Dumping Case

China launched anti-dumping and countervailing duty (AD/CVD) investigations against U.S. broiler products in September 2009. As in Ukraine, a large number of companies registered as interested parties. The Ministry of Commerce of the People's Republic of China (MOFCOM) announced the sampling results. Three companies were selected in the sample to answer AD/CVD questionnaires.

USAPEEC made every effort to fight the case and provided clear evidence that U.S. broiler products had not been dumped, and demonstrated that the Chinese chicken industry suffered no injury from U.S. chicken imports. USAPEEC also argued that the Chinese methodology in calculating the dumping margins was seriously flawed and the AD proceeding did not comply with WTO rules. USAPEEC's proposal for a price undertaking agreement for the suspension of the investigations received strong support from U.S. government, as well as from the China Customs, the Chinese poultry industry, and even the petitioner (China Animal Agriculture Association). Unfortunately, in its quest for resolving unrelated political issues, MOFCOM rejected the proposal.

China imposed preliminary AD duties and CVD duties in February and April 2010, respectively. Then the final AD and CVD duties became effective for five years beginning in September and August 2010, respectively. The AD duties ranged from 50.3 percent for one of the selected three companies to 105.4 percent for non-participants in the investigation, while CVD rates ranged from 4.0 percent to 30.3 percent.

The U.S. government took the dispute to the WTO in September 2011. After consultations proved unsuccessful, the WTO established a Dispute Settlement Panel in January 2012 upon the request of the U.S. Trade Representative's Office. Not surprisingly, in September 2013 the WTO ruled the case in favor of the United States, finding that China violated numerous WTO obligations in conducting its investigations and imposing AD/CVD duties on chicken imports from the United States. However, so far China still has not yet eliminated the restrictive AD/CVD duties.

China has been one of the most important export markets for U.S. broiler products. U.S. broiler exports to China averaged 711,306 metric tons in 2007-2009, accounting for an average of 20.6

percent of U.S. broiler exports worldwide. By comparison, U.S. broiler exports to China in the past four years from 2010-2013 averaged 180,461 metric tons, down 74.6 percent from the average export amount in 2007-2009 (USDA Foreign Agricultural Service's Global Agricultural Trade System). The potential market for broiler meat in China is huge, partly because of its low per capita consumption, large and upwardly mobile population, and rapid increase in consumer income.

The severity of the impact of AD/CVD case on U.S. broiler exports is straightforward. This is particularly true for U.S. exports of chicken paws, as China is the leading export market, and alternative foreign markets are quite limited. Prior to the AD/CVD case, U.S. shipments of chicken paws to China accounted for more than 80 percent of U.S. total chicken paw exports worldwide.

Mexican Anti-Dumping Case

In February 2011, Mexico became the third country to initiate an AD investigation against imports of U.S. poultry, specifically chicken leg quarters and all other leg products. This case is based on the same principles as China and South Africa AD cases. The U.S. industry, the Mexican Poultry Producers Association (UNA), and many public officials in Mexico were surprised by the initiation of the AD investigation, as the U.S. and Mexican poultry industries have a long history of cooperation on various issues. UNA has remained neutral throughout the investigation process.

In January 2012, the Mexican government announced its preliminary determination, with AD margins ranging from 62.9 percent to 129.77 percent. However, Mexican officials elected not to impose these dumping duties until they had rendered a final determination. In the final determination published in August 2012, Mexico identified and applied the rule of implementing the lowest AD duty set at 25.27 percent for the four selected companies that provided sufficient information for calculating individual margins. All other registered companies, along with those companies that did not participate in the AD investigation, would receive “all others” margin set at 127.5 percent.

Subsequently, Mexico chose to suspend the punitive AD duties on U.S. imports to avoid adding to the rising cost of staple foods in Mexico, as the outbreak of highly pathogenic avian influenza in the country in June 2012 already caused price distortions in the Mexican market. So far, the suspension is still in place.

Meanwhile, the U.S. industry – through USAPEEC – has appealed Mexico’s initial finding in the case to a dispute panel established under provisions of the North American Free Trade Agreement (NAFTA). Taking the appeal to a NAFTA panel rather than to the WTO means that a decision can be rendered much more quickly. Also, the industry can initiate a request for the formation of a NAFTA panel, while a WTO appeal would require the government to pursue the case.

U.S. broiler exports to Mexico have increased rapidly since 2007, thanks to full implementation of NAFTA, which allows all U.S. poultry products enter Mexico duty free and without quota limitation. While Mexican broiler production has increased constantly over the years since the implementation of NAFTA in January 1994, domestic demand has increased at a faster pace. In particular, the Mexican meat processing industry has expanded production of value-added products such as sausage and deli meats, using U.S. chicken and turkey meat as raw material.

With the decline in exports to Russia and China, Mexico has been the top export market for U.S. broiler meat since 2010. U.S. broiler shipments to Mexico averaged 523,694 metric tons in 2010-2013, accounting for 14.8 percent of U.S. broiler exports worldwide. Since 2012, Mexico has become the first single market to account for more than $1 billion in combined exports of U.S. chicken and turkey meat, according to U.S. official export statistics.

Russian Ban on U.S. Poultry Products

In retaliation to the economic sanctions imposed on Russia by the West over the situation in Ukraine, Russia banned imports of agricultural products, including poultry, from the U.S., the EU, and several other countries on August 9, 2014.

The impact of the ban on U.S. poultry exports worldwide has been limited, however. Russia, which was once the dominant market for U.S. poultry exports, is no longer as important. Also, global demand for poultry remains strong, lessening the effect of the sudden loss of a single export market. While Russia has remained the third-largest export market for U.S. chicken in recent years, it has accounted for only about 7 percent of U.S. total chicken exports. This compares to as much as 40 percent in the mid-1990s.

With chicken production in Russia increasing at an average annual growth of 19.6 percent in 2000- 2009, Russia dramatically cut its tariff-rate quotas (TRQs) for poultry imports beginning in 2009 to further boost its domestic industry. In 2013, chicken production in Russia surpassed 3.0 MMT, as compared to less than 0.5 MMT in 1995 (USDA Foreign Agricultural Service's PSD database). As its domestic poultry industry has expanded, Russia has become less important as an export market in recent years.

Meanwhile, the diversification effort by the U.S. poultry industry, which USAPEEC has championed for years, has helped U.S. poultry exports to continue to thrive despite multiple setbacks. Russia’s 1996 ban of U.S. poultry planted the seeds for market diversification. The ban was a wake-up call for the industry, as prices for chicken leg quarters - the major poultry item exported to Russia, dropped by half virtually overnight. So many products were left on the market that some producers resorted to sending leg quarters to be rendered into pet food (Toby 2014).

Now U.S. poultry exports have become more diversified than before. For example, in 1994, the U.S. shipped 1.31 million metric tons (MMT) of broiler meat to 80 export markets, 72.6 percent of which went to the top five export markets. By contrast, in 2013, U.S. shippers exported 3.63 MMT of broiler products to 118 countries and regions, with the top five markets accounting for 43.4 percent of the total.

Impact of AI on U.S. Poultry Exports

Impact of AI Occurred in the U.S.

U.S. poultry producers raise their chickens and turkeys in covered structures with controlled access, and biosecurity practices have been a part of raising poultry in the United States for decades. In fact, the United States is one of the few countries in the world that have comprehensive and vigorous programs to prevent, control, and eradicate AI in poultry and, more importantly, prevent AI from becoming a problem to the human population.

However, incidents of low pathogenic avian influenza (LPAI) do occur sometimes in U.S. domestic poultry flocks. As LPAI poses no threat to human health, guidelines established by the World Organization for Animal Health (OIE) recommend that poultry trade should not be restricted on basis of LPAI. Under OIE guidelines, detections of AI viruses of the subtypes H5 and H7 are considered to be “notifiable,” regardless of whether they are low pathogenic or highly pathogenic, and that a country is obligated to notify the OIE in the event of any such occurrence of these subtypes.

Some countries (e.g. China, Japan, Philippines, and Russia), however, do not observe OIE guidelines regarding notifiable LPAI to the letter, and impose import restrictions on countries that report findings or detections of LPAI, regardless of severity. The U.S. government and industry agree that import restrictions based on LPAI are excessive, are not in keeping with the spirit of OIE and its guidelines, and are essentially employed as trade barriers.

In February 2004, an outbreak of HPAI (H5N2) virus was reported in a flock of 7,000 chickens in south-central Texas. At that time, this was the first outbreak of HPAI in the United States in 20 years. No transmission of HPAI (H5N2) virus to humans was reported (U.S. Centers for Disease Control and Prevention).

As a precaution and in response to an HPAI (H5N2) outbreak in British Columbia, Canada in November 2014, USDA began enhanced surveillance of poultry premises and of wild bird mortality events along the U.S.-Canadian border. Since December 2014, USDA has confirmed several cases of HPAI (H5) in the Pacific, Central, and Mississippi flyways (or migratory bird paths). The virus has been detected in wild birds, as well as in a few backyard and some commercial poultry flocks. No human cases of these HPAI H5 viruses have occurred in the United States, Canada, or internationally (USDA Animal and Plant Health Inspection Service).

As of May 8, 2015, 132 HPAI detections on commercial poultry flocks had been reported in eight states, including Arkansas, California, Iowa, Minnesota, Missouri, North Dakota, South Dakota, and Wisconsin. More than 25 million commercial egg-laying hens and approximately 6 million turkeys were culled by state and federal animal health agencies in an attempt to control the spread of the virus, and to ensure that no meat or eggs from the infected flocks entered the food chain.

As a result of the outbreaks, more than 40 countries have imposed restrictions on U.S. poultry and egg products, including breeding stocks and hatching eggs. Although most of these countries have limited their import restrictions to the affected states or to the affected counties within those states, a few countries including China, South Korea, and South Africa have imposed bans on all imports of poultry, eggs and related products from the entire United States.

Impact of AI Occurred in Foreign Countries

In Asia and Africa, the prevalence of subsistence farming of backyard poultry and the inability of governments to implement appropriate control measures could spell a major production disaster. As shown in Figure 2, HPAI outbreaks occur primarily in Asian and African countries. There were 579 HPAI outbreaks worldwide in the past 12 months ending on October 17, 2014. Of those, 71.3 percent or 413 outbreaks occurred in Asia, and 28.2 percent or 163 outbreaks were in Africa. The only case reported in North America occurred in Canada on January 1, 2014. The two cases in Europe occurred in two different locations in Russia on September 1, 2014. During the same period, all 343 LPAI outbreaks occurred in Asia.

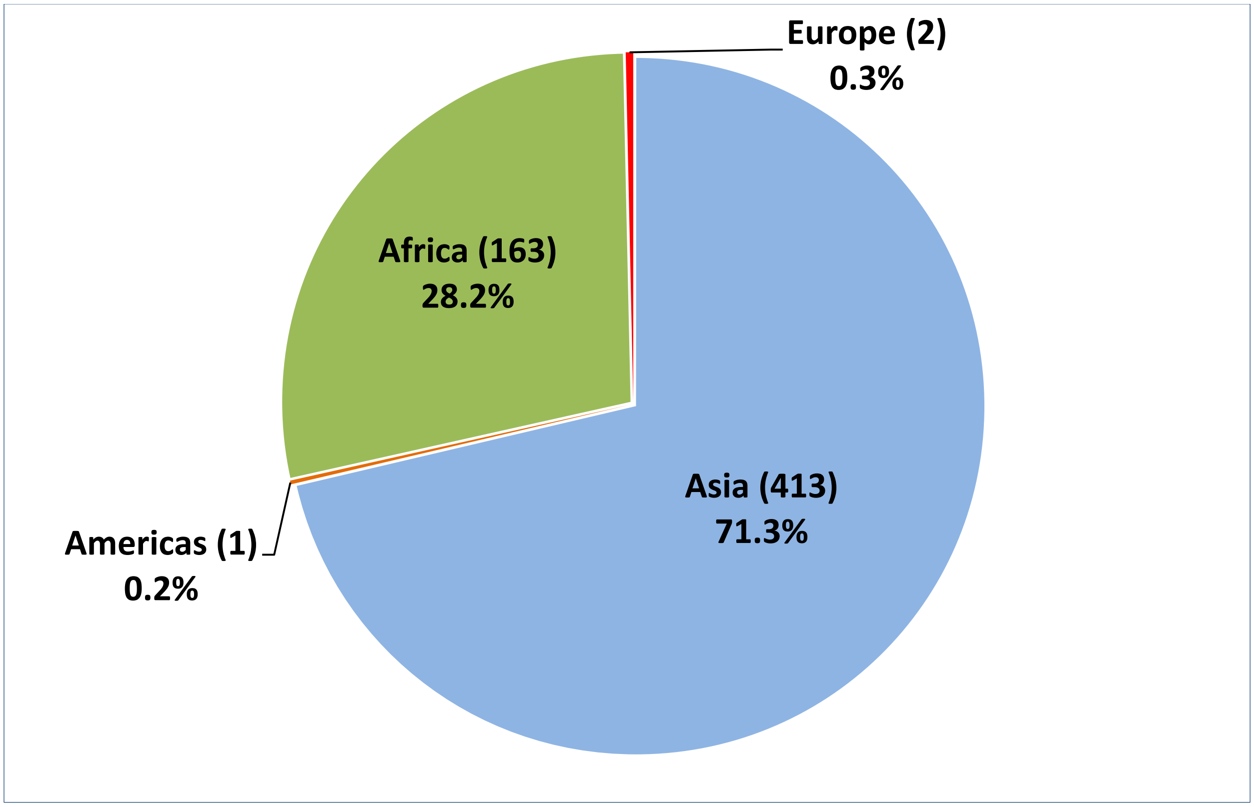

Figure 2. Global HPAI outbreaks by region in the last 12 months (as of October 17, 2014)
Source. FAO/ EMPRES Global Animal Disease Information System

It is straightforward that AI outbreaks negatively affect commercial poultry production in the AI-stricken countries, as a portion of the poultry flocks either die from the disease, or must be destroyed in order to control the outbreaks. For example, the AI outbreaks in Asia in late 2003 and early 2004 led to a depopulation of more than 100 million birds in the affected eight countries of Cambodia, China, Indonesia, Japan, Laos, South Korea, Thailand, and Vietnam (U.S. Centers for Disease Control and Prevention). Chicken production in Thailand and Vietnam in 2004 decreased by 32.8 and 15.3 percent from a year earlier, respectively, as a result of the outbreaks (USDA Foreign Agricultural Service's PSD database).

Poultry consumption in countries with AI outbreaks also tends to decrease during the outbreaks and to remain at low levels for a few months afterward, as some consumers reduce their consumption of poultry out of fear of contracting influenza, or stop eating poultry altogether. However, the decrease in consumption generally tends to be less than the decrease in production. Impact on consumption for imported poultry products tends to be less significant than that for domestically produced poultry products. The negative impact on international poultry exports prices tends to be temporary (Taha 2007). And the impact on import demand for U.S. poultry products varies significantly across the countries, depending on consumers' risk perceptions in the AI-stricken countries.

For example, the HPAI outbreaks in Mexico in June 2012 led to a significant depopulation of the poultry flocks in the country, while Mexico's domestic demand for poultry products remained strong. Even as Mexico increased imports of breeding stock and hatching eggs from the United States to help expand its poultry production, domestic poultry supply still further lagged behind domestic demand. As a result, U.S. poultry exports to Mexico in the second half of 2012 reached 408,350 metric tons, an increase of 21.5 percent over the same period a year earlier. This compares to an average growth rate of 7.8 percent for the second half of year from 2000 to 2011.

Similarly, HPAI outbreaks in Mexico in January 2013 retarded Mexican poultry production, while Mexican domestic consumption continued to increase. As a result, U.S. poultry exports to Mexico in 2013 jumped to 859,024 metric tons, an increase of 11.8 percent from 2012. This compares an average annual growth rate of 8.3 percent in 2000 -2011.

For China, HPAI outbreaks occur almost every year. Yet the HPAI outbreaks in March 2013 received much attention and media coverage, as the H7N9 virus infected both birds and humans. Most of the cases of human infection reported exposure to live poultry or potentially contaminated environments, especially the live bird markets. Most patients infected with H7N9 became severely ill and 21 people died in the three weeks since the infection in humans were found for the first time (China - WHO Joint Mission, 2013). Many consumers in China lose their appetite for poultry in response to the deadly HPAI outbreaks.

As a result, China's poultry imports dropped significantly in the following three months in succession after the outbreaks in March 2013 (Figure 3). Specifically, China's poultry imports in March 2013 were 66,246 metric tons, while imports in June 2013 were 39,460 metric tons, down 26.4 percent from the average poultry import amount of 53,605 metric tons for the month of June in 2008-2012. However, China's poultry imports began to pick up again after June 2013. Total poultry imports in 2013 reached 584,174 metric tons, up 12.0 percent from 2012.

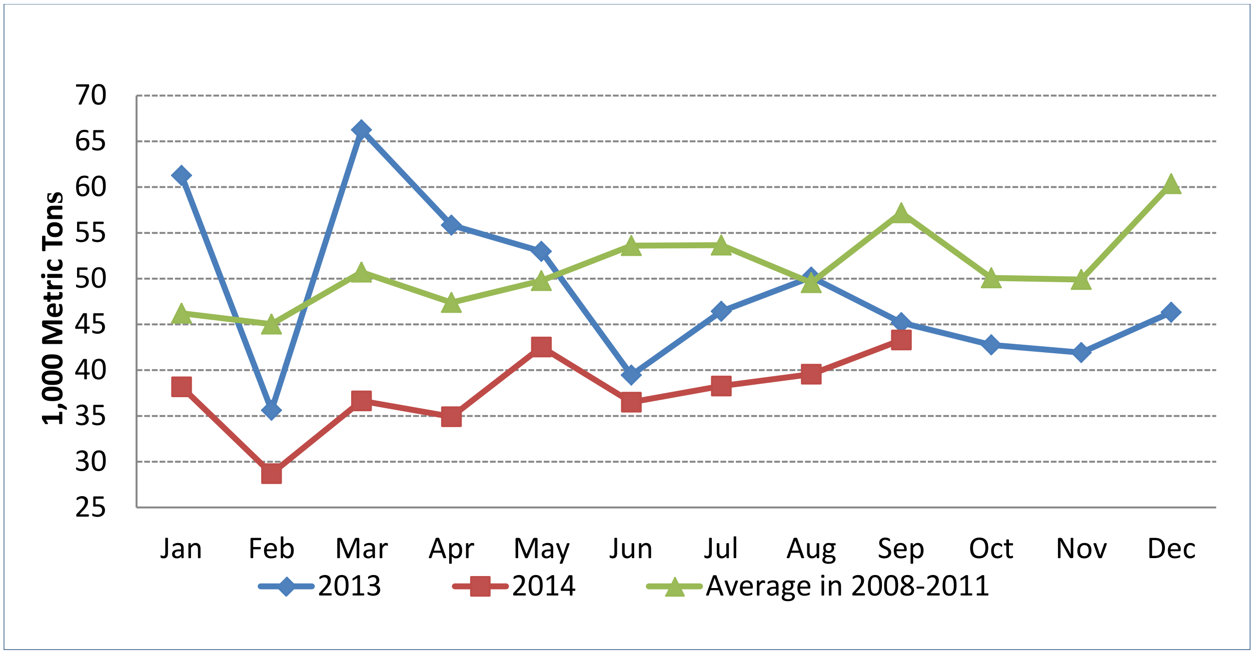

Figure 3. China Poultry Imports (frozen products only)
Source. China Customs (via the Global Trade Atlas)

Religious and Cultural Trade Barriers

Religious and cultural trade barriers are often encountered in predominantly Muslim countries. For example, entry to Malaysia, Indonesia, and Saudi Arabia must meet halal requirements, meaning poultry should be raised, slaughtered, and processed in accordance with Islamic rites. However, definitions, interpretations, and regulations of halal vary widely from country to country in both print and practice.

Total population in the Muslim countries is predicted to increase from 1.64 billion in 2013 to 2.14 billion in 2030, an average annual growth of 1.6 percent. This compared to an average annual growth of 0.8 percent for non-Muslim countries. That is, population in Muslim countries by 2030 will account for more than 25 percent of world total population (FAOSTAT). Increased population in the Muslim countries will favor poultry consumption.

In the past decade ending in 2013, U.S. poultry exports to Muslim countries increased from 233,995 metric tons in 2004 to 630,873 metric tons in 2013, an average annual growth of 11.7 percent. Of which, about 60 percent of the exports were shipped to the top five Muslim countries, including Iraq, United Arab Emirates, Kazakhstan, Jordan, and Saudi Arabia. Currently, about 14 percent of U.S. total poultry exports are shipped to Muslim countries. By contrast, 43 percent of Brazilian poultry exports are destined for Muslim countries.

Export Competition with Brazil

The U.S. and Brazil have dominated global exports in both broiler and turkey in the world market. The U.S. is the single most important turkey exporter in the world, with an export market share of more than 46 percent in recent years, while Brazilian export share in the world market is about 24 percent. The U.S. is expected to continue to dominate the world turkey market in the future.

For broiler exports, the two countries do not compete head-to-head in the world market as they sell differentiated chicken products. The majority of U.S. broiler exports are chicken leg quarters and other chicken leg meat. By contrast, the majority of Brazilian broiler exports are deboned chicken breast meat, further processed chicken products, and small whole birds.

Brazilian poultry exports benefit from Brazil's AI-free status. Brazilian packaging and greater flexibility by their government (reissuing export certificates for changes in consignees) are highly regarded by importers. Brazil will continue to dominate the Japanese market because Japanese consumers prefer labor-intensive boneless items and specialized cuts. The U.S. is less competitive in the Japanese market as labor cost in the U.S. is much higher than that in Brazil. For the EU market, the U.S. cannot compete with Brazil simply because that EU has banned U.S. poultry since 1997, as discussed earlier.

The overall competitiveness of U.S. poultry exports in the world market is strong as the U.S. has a relatively low-cost and high-quality feed supply, good bio-security practices, and consistent and stable government regulations. The impact of of Brazilian competition on U.S. exports in the near future is expected to be manageable due to a separation in key export markets for the two major exporting countries along with increasing world demand for more affordable chicken products.

Conclusions

This study explores key factors that affect U.S. poultry exports. Protectionism will remain one of the biggest challenges facing U.S. poultry exports in the near future. However, despite many trade obstacles, we expect a positive outlook for U.S. poultry exports in the next decade due in part to the following reasons:

First, poultry is the most efficient converter of feed, its production demands less water and energy, uses less arable land, and emits less greenhouse gases than red meat production. We expect that global poultry production and consumption will continue to increase as the importance of feed efficiency and protecting the environment become higher priorities for producing countries. Second, consumer income in developing countries will grow faster than in in developed countries throughout the next decade. Higher income in developing countries will lead to higher poultry consumption, as per capita poultry consumption in developing countries is in general much lower than that in developed countries. Third, growth in world population, in particular, increased population in Muslim countries will favor poultry consumption. In addition, urbanization and westernization of food in developing countries will help boost poultry imports. Fourth, domestic poultry consumption in most developing countries is expected to increase at a faster pace than domestic poultry production. That is, import demand for poultry by most developing countries will continue to increase in the future.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Factors Influencing Export Value Recovery after Highly Pathogenic Poultry Disease Outbreaks

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Abstract

Many factors influence a country's international poultry market accessibility, including freedom from diseases such as highly pathogenic avian influenza and highly pathogenic strains of Newcastle disease. This study examines OIE-reported events of these two diseases over a 16-year period to determine the factors that contributed significantly to trade revenue recovery time. Results indicate that the elements influencing a measurable negative export revenue effect due to disease—including risk perceptions and whether the disease is zoonotic—differ from the elements that influence the length of revenue recovery, such as product affordability. In addition, overall global economic health and growing meat demand are elements that matter at the time an event occurs. The magnitude of elements influencing trade revenue during disease events suggests that recovery from HPAI and ND events may take months, not years.

Keywords: trade, poultry, highly pathogenic avian influenza, Newcastle disease

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Introduction

Trading partners may impose trade bans on live birds, poultry products, hatching eggs, and egg products during or after highly pathogenic poultry disease events, such as highly pathogenic avian influenza (HPAI) and highly pathogenic strains of Newcastle disease (ND). For countries that export a large proportion of their poultry production, these trade bans can be very costly. A multitude of elements may influence the length of market recovery after a disease event, such as disease type, product type and value, world supply, disease management timelines, disease event size and duration, and country credibility (FAO 2006). In addition, political changes, price changes, weather, and consumer response can impact the length of export market recovery. Although trade restrictions have been used in response to low pathogenic avian influenza events, this research focuses on HPAI and ND events reportable to OIE.

In the last two decades, HPAI and ND events have occurred in areas previously free of those diseases, especially with the introduction and spread of the H5N1 strain of avian influenza. The World Organization for Animal Health (OIE) guidelines suggest that a country previously free of avian influenza can regain its disease-free status three months after the last bird has been destroyed, all premises are disinfected, and surveillance conducted (OIE 2014a). ND outbreaks meeting OIE criteria[1] for being highly pathogenic are reportable, and the guidelines suggest disease freedom status is restored after three months following similar culling, disinfection, and surveillance criteria (OIE 2014b). The OIE defines Newcastle disease to include infection among poultry, which includes all domesticated birds used for the production of meat or eggs for consumption, products, restocking supplies, or breeding (OIE 2014c). Birds kept in captivity for other reasons and wild birds are not considered poultry, so ND in wildlife is not required to be reported. Economic consequence estimates for livestock disease events tend to be sensitive to export market reaction assumptions, especially in the case of a large world exporter. However, little information is available on which to base assumptions of export market reactions other than OIE guidelines.

Importing countries make three decisions in response to a disease event: 1) whether to ban imports from a country with an HPAI or ND outbreak, 2) whether a trade ban will apply to the entire country or a specific geographical area, and 3) the amount of time a ban will remain in effect. It is generally assumed that a trade ban will occur for a country that exports poultry products with some risk of disease spread. Expectations on trade bans due to sanitary restrictions in turn affect domestic markets and producer behavior (Ruhl 2009), making expectations of trade consequences an important part of poultry disease consequence analysis. Little trade consequence research has been done on ND. For HPAI, some analysts have used the OIE three-month guidelines to develop trade resumption scenarios for economic impact analyses. These researchers also noted that the observed length of export bans did not always match OIE

[1] Newcastle disease is defined by OIE as an infection of birds caused by a virus of avian paramyxovirus serotype 1 (APMV-1) that meets one of the following criteria for virulence: a) the virus has an intracerebral pathogenicity index (ICPI) in day-old chicks (Gallus gallus) of at least 0.7, or b) multiple basic amino acids have been demonstrated in the virus (either directly or by deduction) at the C-terminus of the F2 protein and phenylalanine at residue 117, which is the N-terminus of the F1 protein. Source. http://www.oie.int/fileadmin/Home/fr/Health_standards/tahm/2.03.14_ NEWCASTLE_DIS.pdf.

guidelines, and the lifting of bans did not always mean the export market recovered immediately (Paarlberg 2007; Junker et al. 2009; Hagerman et al. 2012; Philippidis and Hubbard 2005).

Current research builds off previous work that summarized disease events affecting poultry and elements hypothesized to contribute to export market recovery times (Johnson et al. 2011; Johnson and Stone 2011a, 2011b). In addition, Johnson and others (2012) looked at events of eight different diseases affecting multiple species, including poultry, and found the percentage of a country's exports destined for Asian countries had the greatest potential to lengthen export market recovery time; however, poultry was not examined explicitly. Because the model was not statistically significant, no confidence could be placed on the conclusions.

One consideration is that trade partners may wait for additional proof of disease freedom or have already changed product source countries (Park et al. 2008), which will effectively extend trade revenue recovery beyond the OIE's three-month wait period to regain disease-free status. Several studies have examined scenarios with extended trade revenue recovery times in which trade markets were assumed to be fully closed down for multiple years (Morgan and Prakash 2006; Nogueira et al. 2011; Hayes et al. 2011). Disease events that have the potential to be zoonotic[2] are associated with longer export market recovery times (Morgan and Prakash 2006). Certain strains of HPAI have been known to transmit from poultry to humans, causing a wide range of potentially life-threatening symptoms. Since 2003, hundreds of human HPAI H5N1 cases have been reported primarily in Asia, making it an important zoonotic disease. ND infections in humans can cause mild conjunctivitis and influenza-like symptoms, mostly resulting from occupational exposure. ND is not considered an important zoonotic disease. Further, no human cases of ND have occurred from eating poultry products (CFSPH 2008).

To date, no analysis has focused on trade recovery times shorter than the OIE guidelines. The potential for widely varying trade recovery estimates has led to the use of stochastic methods for trade recovery estimation (Niemi and Lehtonen 2011, 2014). However, additional analysis of observed trade recovery is needed to develop distributions for this stochastic methodology.

This research contributes toward filling a gap in the trade and animal health economics literature by identifying and quantifying the elements that influence global poultry trade after HPAI and ND events. In order to accomplish this, the authors evaluated 71 HPAI and ND events to determine what factors have a significant influence on the amount of time needed to achieve export market recovery. Since ND and HPAI affect poultry and have similar sanitary restriction guidelines, the information from this research will be useful in refining export market reaction parameters as researchers develop scenarios for models to estimate the economic impacts of poultry diseases.

[2] OIE defines zoonosis as any disease or infection which is naturally transmissible from animals to humans. Source. http://www.oie.int/index.php?id=169&L=0&htmfile=glossaire.htm.

Data

The OIE website reports detailed information about disease events, including how many outbreaks are associated with the event. Each observation in the dataset used in this analysis represents a highly pathogenic poultry disease event in non-endemic countries, using that country's geopolitical borders to define the area. The dataset contained observations on 71 HPAI and ND events affecting birds in 25 countries on 5 continents[3] between September 1998 and August 2013. Geographical proximity of countries experiencing HPAI and ND events was examined to determine if a combination of some outbreaks was actually one event that crossed geopolitical borders. However, the cross-border clustering of outbreaks only appeared obvious in one location—ND outbreaks in Belgium and the Netherlands in 2009. Thus, clustering of outbreaks across country borders was not incorporated further into the analysis. Summary statistics for the variables included in this analysis are presented in Table 1.

Export market recovery (referred to as "recovery") was defined as the months elapsed from the first announcement of a poultry disease event until a country's monthly export revenue from poultry exports (poultry and poultry products) met or exceeded the expected monthly revenue of poultry exports. The expected monthly revenue of poultry exports was calculated using a two-year running average prior to the disease event; the average was based on the same month in the prior two years and represented the expected level of revenue if market conditions had not been interrupted by the disease event. For example, in September 2003, the two-year running average was the average of export revenues for September 2001 and September 2002. A two-year running average was chosen because export revenues include historical market conditions prior to the disease event; however, using more than two years of history could introduce variability from events that may no longer be affecting market conditions. Monthly export revenues for the 25 countries were collected for relevant poultry and poultry from Global Trade Atlas (GTA – Global Trade Information Services, Inc.).

The "recovery" is the dependent variable in this analysis, and it captures the aggregated influence of different aspects considered in the three-part decision-making process made by international trading partners in the face of a highly pathogenic poultry disease outbreak. The first decision is whether the disease event poses a health threat to the importing country's domestic poultry industry, justifying the use of sanitary restrictions in the form of a trade ban. The second decision is if the ban will be applied country-wide or to a specific geographic area. The third decision is how long those restrictions should last, conditional on a sanitary restriction being imposed.

The mean "recovery" for this dataset was 1.85 months, which is less than the 3 months suggested by OIE guidelines. The maximum is 11 months. Forty of the 71 (56%) HPAI and ND events had the minimum of zero for "recovery." A zero "recovery" indicates the monthly revenue received from poultry exports met or exceeded the expected monthly revenue from poultry exports for the

[3] North America: Canada, Mexico, United States; South America: Brazil, Chile; Europe: Austria, Belgium, Denmark, France, Germany, Greece, Hungary, Italy, Netherlands, Poland, Spain, Sweden, Switzerland, Turkey, United Kingdom; Asia: China, Japan, South Korea, Taiwan; Oceania: Australia.

month of the outbreak announcement. This is an interesting characteristic of this dataset in that it implied that any bans made by importing trade partners had no measurable negative poultry export revenue effect when HPAI and ND events occurred in certain countries. Some short-term volatility could have occurred in that initial month; however, there was not a net loss over the course of the month. This overrepresentation of zeroes in the dependent variable posed an empirical challenge, which will be addressed in the methodology section.

Disease event information was collected from the World Animal Health Information System, maintained by OIE, to create four variables that described each specific event: duration, repeat, zoonotic, and wildlife. “Duration” was measured from the first announced case (infected bird) to the last case reported, and the mean event duration was 7.56 months. On average, countries with highly pathogenic poultry disease events in the dataset experienced “recovery” (1.85 months) prior to the end of the event. If a country did not have a case for six months, it was considered free of disease and any subsequent cases were treated as a new event, more specifically as a “repeat” event of the same disease in the same country. About half (54%) of the disease events were “repeat” events.

Table 1. Summary statistics of full poultry disease event data

Common Name	Variable Description	Unit	Mean or Proportion	Minimum	Maximum
Recovery[1]	Export market recovery	Months	1.85	0.00	11.00
Duration	Event duration	Months	7.56	1.00	123.00
Repeat	Repeat disease event	0,1	0.54	--	--
Zoonotic	Zoonotic	0,1	0.55	--	--
Wildlife	Infected wildlife only	0,1	0.28	--	--
Eventcount	Count of other simultaneous event announcements	Number	1.73	1	5
Exports2Asia	Percent of export revenue from products destined for Asian countries	%	28.09	0.38	99.93
Share	Share of world export market	%	3.49	0.00	17.35
Freshfrozen	Percent fresh-frozen	%	69.22	7.08	99.04
Perdif	Percent change in export revenue in 1st month of event	%	18.33	-86.03	194.80
GDP	Percent change in global gross domestic product	%	3.15	-4.31	5.20
PerCapita	Global per capita consumption of poultry meat	kg	11.42	8.05	13.10
ER	Exchange rate	$	98.08	72.15	133.59
Agrarian	Majority of producers follow traditional production practices and marketing channels	0,1	18.31	--	--

[1]Dependent variable

There were 32 ND events and 39 HPAI events, and the HPAI events were of the following strains: H5N1, H7N1, H7N2, H7N3, and H7N7. Strain H7N1 is the only strain in this dataset not known to have zoonotic capabilities. However, that event coincided with an H5N1 event, so the indicator variable for zoonotic disease events “zoonotic” was 1 for all HPAI events and 0 for all ND events. If the disease event affected only wildlife (the disease did not enter the commercial poultry flock), the indicator variable “wildlife” was 1 for affecting wildlife only and 0 otherwise. Eight ND and 12 HPAI events (28%) affected only wildlife. Since wild birds are not considered poultry, ND in wildlife is not required to be reported immediately. All of these wild bird ND events were reported within a year, but not all were reported in the month the event occurred.

Using these event data, a variable was created for the number of simultaneous highly pathogenic poultry disease events announced in the same month by other countries (“eventcount”). The mean “eventcount” was 1.39 events and this variable accounted for an importing country’s ability to perceive and manage risk based on the disease status of export market competitors.

Using the export revenue information, four variables were created to explain historical trading patterns of the country experiencing the poultry disease event. These variables were calculated using the two-year average of the percentage of export revenues:

- from poultry products destined for Asian countries (“exports2Asia,” mean 28.09%);
- received by a country divided by total value of world exports (“share,” mean 3.49%);
- and generated from fresh or frozen poultry products divided by the total export revenue of poultry products (“freshfrozen,” mean 69.22%).

In addition, the authors calculated the percentage difference between the expected and actual poultry-product export revenue (“percentdif”) in the month a poultry disease outbreak was announced to capture the initial change in poultry product export revenue. The “percentdif” was negative for events that experienced “recovery” of one or more months and positive for those events with zero “recovery.”

The last three independent variables characterized the health of the global economy, global meat demand, and the relative price of goods from the country experiencing the disease event. The percentage change in global gross domestic product (GDP) is the average monthly percentage change in real-world GDP for the duration of the export market recovery time, collected from the International Financial Statistics of the International Monetary Fund. The global per capita consumption of poultry meat (“PerCapita”) was collected from the Organisation for Economic Co-operation and Development and the global per capita consumption variable used in this analysis is the two-year annual average prior to the disease event. The exchange rate (ER) is a regional trade-weighted exchange rate of the month prior to the first announcement of a poultry disease divided by the average monthly regional trade-weighted exchange rate for the duration of the export market recovery time. For those disease events that had zero months in export market recovery time, the regional trade-weighted exchange rate of the month of the outbreak announcement was used. Data for calculating the exchange rate variable came from USDA–Economic Research Service.

The variable "agrarian" indicated that a majority of the producers in an exporting country followed traditional production practices and marketing channels, such as live bird markets. The countries included in this variable were Chile, China, Hungary, Mexico, South Korea, Taiwan, and Turkey. This subjective categorization was based loosely on the FAO classification of poultry production systems,[4] considering these countries at the time the outbreak occurred. Sectors 3 and 4 under the FAO classifications have more subsistence farms with minimal biosecurity and greater use of live bird markets.

Table 2. Summary statistics of poultry disease event data for observations with a recovery time.

Common Name	Variable Description	Unit	Mean or Proportion	Minimum	Maximum
Recovery	Export market recovery	Months	4.23	1.00	11.00
Duration	Event duration	Months	12.13	1.00	123.00
Repeat	Repeat disease event	0,1	0.35	--	--
Zoonotic	Zoonotic	0,1	0.65	--	--
Wildlife	Infected wildlife only	0,1	0.29	--	--
Eventcount	Count of other simultaneous event announcements	Number	1.97	1	5
Exports2Asia	Percent of export revenue from products destined for Asian countries	%	34.38	0.95	99.93
Share	Share of world export market	%	3.51	0.00	17.35
Freshfrozen	Percent fresh-frozen	%	67.91	12.08	99.04
Perdif	Percent change in export revenue in 1st month of event	%	-18.43	-86.03	-0.66
GDP	Percent change in global gross domestic product	%	3.44	-4.31	5.20
PerCapita	Global per capita consumption of poultry meat	kg	11.18	10.10	13.10
ER	Exchange rate	$	101.29	97.73	107.38
Agrarian	Majority of producers follow traditional practices and marketing channels	0,1	25.81	--	--

Of particular interest were those events where a "recovery" was experienced. Summary statistics for the 31 observations that experienced a "recovery" are presented in Table 2. When compared with summary statistics in Table 1, the 31 events with a non-zero "recovery" have, on average, longer "duration," fewer "repeat" events, more "zoonotic" events, more "agrarian" countries, higher "exports2Asia," and the "percentdif" statistics are negative.

[4] http://www.fao.org/docs/eims/upload/214190/ProductionSystemsCharacteristics.pdf

Methodology

The methodology used to examine the cross-sectional data associated with HPAI and ND events is a zero-inflated negative binomial (ZINB) regression model, which accounts for excessive zeroes and over-dispersion of the dependent "recovery" count variable. The ZINB model estimates the influence of various components on "recovery" when it is one or more months. Therefore, any bans imposed by an infected country's trade partners had a measurable negative trade revenue effect and consequently results in time needed for "recovery."

The ZINB simultaneously estimates the influence of components on all three decisions made by importing countries as they are reflected by measurable export revenue changes. Since 56% of the events showed no export revenue loss relative to a historical trend, these events had a zero count value for "recovery," and therefore a zero-inflated model was an appropriate model. In addition, the variance of our dependent variable recovery time was large (9.36) relative to its mean (1.85), suggesting over-dispersion in the data, confirming our choice of a ZINB model as opposed to the zero-inflated Poisson regression. The benefit of using the ZINB model is that the negative binomial distribution does not assume equal mean and variance.

While theory suggests the ZINB model was the best specification, other models were explored as alternatives including a two-stage regression model that used a logistic regression to estimate whether a country would have an export revenue impact or not. We looked at the predictive power of these models by predicting the ex post outcomes of the data set.

$$(1) \qquad Model\ Predictive\ Score = \sum_j (Predicted\ Recovery_j - Actual\ Recovery_j)^2$$

By taking the difference of the terms and squaring them, we created a way to score each model. In all comparison models the ZINB model had the lower score, suggesting the better predictive model.

For the ZINB model used, the standard logistic, or logit, link function was assumed. This link function estimates the process that generates the excess zeroes. The logit function estimates components that contribute to zero "recovery." The log likelihood function can be specified as (StataCorp 2013):

$$(2) \qquad \ln L = \sum_{j \in S} \ln\left[F_j(\mathrm{z}_j\gamma) + \left(1 - F_j(\mathrm{z}_j\gamma)\right) p_j^m\right] + \sum_{j \notin S} [\ln(1 - F_j(\mathrm{z}_j\gamma)) + ln\Gamma(m + y_j) - ln\Gamma(y_j + 1) - ln\Gamma(m) + mlnp_j + y_j \ln(1 - p_j)]$$

Where: $m = 1/\alpha$

$p_j = 1/(1+\alpha\mu_j)$

F_j = inverse of the logit link

$\mu_j = \exp(x_j\beta)$

$$S = \{y \mid y_j = 0\}$$

Note the logistic function was included in both the estimation for determining a count of zero and for the estimation of the count variable. This implies that the two components are solved simultaneously. The difference between $z_j\gamma$ and $x_j\beta$ are the different functional components of the model. The z_j variables are those components that contribute to a zero count and γ is the vector of coefficients to be estimated; these include "wildlife," "share," "eventcount," "agrarian," "zoonotic," and "repeat." The probability of a zero count is determined by the logit function as well as the count function, where p_j accounts for the count function and F_j accounts for the logit function. The x_j variables influence the number of recovery months with β being the estimated vector of coefficients that include "duration," "repeat," "wildlife," "zoonotic," "eventcount," "exports2Asia," "share," "freshfrozen," "perdif," "gdp," "percapita," "er," and "agrarian." The zero-inflated component included variables that would be known at the time of the event announcement and would potentially influence the initial trade ban decision. The count component includes all possible variables, including variables reflecting event response information influencing decisions on the geographic extent of trade restrictions and duration of recovery.

Results

The ZINB results showed a significant model with a Wald Chi^2 of 319.77 (p value of the Chi^2 <0.00). The lnalpha p value was <0.00, confirming the choice of a negative binomial over the simpler Poisson model. The zero-inflated regression coefficients are reported in Table 3. The zero-inflated component of the regression model was interpreted as the influence independent variables have on changing the odds of observing a zero in "recovery." The sign indicates whether the odds of observing a zero increase or decrease. A variable that increased the odds of observing a zero included the occurrence of a disease event where the infection occurred only in "wildlife" populations. In addition, as more simultaneous events were announced in the same month by competing export countries ("eventcount"), the greater the odds a country would have a "recovery" of zero months. We posit that, as the number of simultaneous events increases, importers learn more about their risk of infection and refine their responses as a result.

However, if the majority of producers in the exporting country experiencing a poultry disease event follow a traditional style of production and marketing ("agrarian"), the poultry disease is known to have zoonotic capabilities ("zoonotic"), or the event is a repeat event (repeat"), the odds that country would have a zero "recovery" decline.

The count component of the ZINB model indicated the factor by which recovery time would be multiplied. For example, disease event duration changed the revenue recovery time by a factor of 1.01. This result means that as the duration of the disease event grew longer, so did the time to trade recovery, but not as much as the exchange rate, which had a factor of 1.18. As the exporting country's exchange rate became stronger relative to the U.S. dollar, the export goods become relatively more expensive on the world market. Or, if a country's exchange rate were to decline, making export goods relatively less expensive on the world market, the country's revenue recovery occurred more rapidly. The other variable that significantly lengthens "recovery" is number of total events occurring in that same time period around the world ("eventcount"). For each additional event of that same disease (HPAI or ND), the revenue recovery time changes by a factor of 1.17.

Table 3. Results of zero-inflated negative binomial model.

Zero-Inflated Component	
Variables	**Odds Ratio**
Constant	**-6.55
Wildlife only	***17.94
Share of world export market	-0.46
Count of other events	***5.52
Agrarian	***-38.86
Zoonotic	***-53.49
Repeat	***-16.79
Count Component	**Relative Ratio**
Constant	***0.00
Event duration	***1.01
Repeat	***0.32
Wildlife Only	0.95
Zoonotic	1.02
Count of other events	**1.17
Percent of exports to Asia	1.01
Share of world export market	1.02
Percent fresh-frozen	1.00
Percent change in export revenue in 1st month of event	***0.97
Agrarian	*0.65
Percent change in global GDP	***0.91
Per capita consumption	1.00
Exchange rate	***1.18

Note. Asterisks denote a statistically significant difference at the 10 percent (*), 5 percent (**), and 1 percent (***) levels.

Interestingly, if the current HPAI or ND event was preceded by another event of the same disease (by at least 6 months), the exporting country could expect market recovery time to change by a factor of 0.32 compared with non-repeat events. If the majority of a country's producers are "agrarian," the expected "recovery" will change by a factor of 0.65. An increase in "perdif" changes recovery time by a factor of 0.97; however, it is important to note the meaning of an increase in "perdif." Countries that have a trade recovery necessarily have a negative change in revenue during the first month of the events, so an increase in "perdif" is actually making the initial shock to export revenue smaller. Thus, an interpretation of this factor is that a smaller initial revenue loss is more quickly recovered. Finally, as the global economy strengthens, measured by the percentage change in global GDP, demand increases and "recovery" is shorter, as indicated by the factor 0.91.

Discussion

The results are interesting to consider in the context of the three decisions importing countries make when their suppliers experience highly pathogenic avian disease events. First is the decision of whether or not to impose restrictions on poultry products originating from the country where the event is happening, as indicated in the zero inflated component. This decision appears to be based largely on perception of risk for the spread of avian disease from the country where the event occurred and on a general risk perception. The largest component influencing the odds of observing a non-zero recovery time is the threat to human health posed by HPAI strains with zoonotic potential.

The second decision importing countries make is whether to recognize limited disease control areas, as examined in the count component of the model. Recognition of limited disease control areas or 'regionalization' is developed in bilateral agreements. Since initially applying trade bans to a region will be highly correlated with the "perdif" variable, some impacts of regionalization are represented in the model. The percent difference in poultry product export revenues would include any trade revenues realized as a result of importing countries accepting a regionalization strategy proposed by exporters. Thus, if a regionalization strategy is used for trade bans then the percent change in expected revenue ("perdif") would be smaller than if the country did not regionalize. This analysis did not specifically examine the potential impact of decisions to accept regionalization beyond the first month due to the lack of information available on all bilateral agreements made during these disease events.

The third decision importing countries make is how long to keep restrictions in place, also examined in the count component of the model. Disease specific aspects, such as duration, play a role in determining how quickly export revenue recovers, but other general economic aspects like GDP and exchange rate also contribute to export revenue recovery. This means that expectations on future poultry disease consequence analyses may need to be more multifactorial than many *ex ante* analyses have considered in the past.

To interpret the results of the second and third decisions in more practical terms of months and weeks, consider the following. While holding all other variables constant and using the mean "recovery" of 4.23 months in this dataset, a country experiencing a highly infectious poultry disease event could expect to have a 1.4-month shorter "recovery" if the event is a repeat. A country could expect to have a "recovery" that is three weeks (0.72 months) longer for each additional event that is announced in the same month in different countries, when holding all other variables constant. These are two examples of how such components can impact (increase or decrease) "recovery" and the magnitude of influence on "recovery."

While a single component can change “recovery” by a little over a month, components will interact with each other when they occur simultaneously in a highly infectious poultry disease event. However, the magnitudes presented here indicate that situations in which export revenue recovery takes years for HPAI and ND is probably less common than one might think. Since export revenue reflects both changes in the price and quantity of goods exported, industry flexibility may speed revenue recovery through changing product types for export. Since the dependent variable is calculated based on the level of poultry and poultry product export revenues after an outbreak announcement (compared to the two year running average), this includes the changes in revenue received from exports of cooked and processed products. This was the case in Thailand after the HPAI event in 2003 (Sirimongkolkasem 2007).

Finally, only three of the independent variables considered had a significant influence on importer decisions in both components of the model — “eventcount,” “repeat,” and “agrarian.” Furthermore, these variables appeared to feature differently into each decision. The increase in the number of simultaneous events announced the same month (“eventcount”) increased the chance of a country not having a recovery time, but also lengthened revenue recovery time by a factor of 1.17. This relationship may indicate the influence of both poultry demand and risk perception in the world market. While multiple poultry product sources are experiencing disease simultaneously demand for poultry products must still be met. “Eventcount” may also represent collective risk aversion after trade barriers are in place, but may not reflect individual country risk aversion that can be impacted by the disease status of the importing country. In a country experiencing a “repeat” of a disease previously reported, the odds of having no measurable negative trade effects decreased; however, “recovery” will be shorter in duration compared with a first-time incident. This relationship may reflect both a perception of risk based on repeated disease events and benefits from prior negotiations to resume trade, or mechanisms already in place for a country to adequately provide proof of disease freedom. For the “agrarian” variable, if the majority of a country’s producers followed traditional production practices and marketing channels, the odds of no measurable negative trade effects decreased; however, “recovery will be shorter in duration compared with industrial countries. This result may point to an importing country’s perception of an “agrarian” country’s ability to respond to a poultry disease event. As evidence of adequate response becomes available, the perceived risk lessens, which results in a shorter “recovery.” These results highlight the complexities involved in trade access decisions based on sanitary concerns.

Conclusions

Assurance of disease freedom is only one of many considerations that influence demand for live birds, eggs, and poultry products on the world market. This analysis showed the influence of other aspects contributing to export market recovery times after a poultry disease event. Tastes and preferences in the form of consumer risk perceptions proved significant, as events of zoonotic diseases resulted in longer recovery times and a smaller initial revenue loss shortened recovery. The importance of regional trade relationships and the health of the global economy influenced recovery time. When looking at the changes in price or affordability of an exporter’s meat products, relative to their competitors, the increase in exchange rate lengthened recovery time. There are other considerations that are difficult to quantify that influence export revenue recovery times, such as political pressures. Our model explains much of the variation in the data, so we are likely capturing some of the variation due to political pressures indirectly.

While this analysis looks at the collective decisions made at the global market level, risk perceptions may vary among specific importing countries depending on their disease freedom status at the time one of their trading partners announces an event. Future research can examine the effect of bilateral variability in trade restrictions and time to export quantity recovery. Estimating time to quantity recovery is more challenging due to the need to measure output units in a common way; however, it may present a valuable extension to the current analysis.

Expectations of trade recovery after an animal disease event are often based on OIE guidelines; however, this study has shown that considerations in export revenue recovery time extend beyond OIE disease status. The context of the global economy and characteristics specific to the country where the disease event occurred also played an important role in determining export revenue recovery. This analysis showed that basic trade theory has trumped those guidelines in specific situations. Furthermore, the variability of observed outbreaks indicates potential effects of importer risk aversion. This study illustrates that in instances of HPAI and ND, export revenues are likely to recover in months rather than years.

Acknowledgements

Global Trade Information Services Inc., Cristobal Zepeda, Ann Hillberg Seitzinger, Lindsey Garber, Mary Foley, Anne Berry and those who provided comments at the 2014 Western Agricultural Economics Association Annual Meeting.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

U.S. Domestic *Salmonella* Regulations and Access to European and Other Poultry Export Markets[1]

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Abstract

U.S. Poultry exports over the past twenty years have risen dramatically. But, concern over *Salmonella* has threatened access to some traditional export markets. This paper examines the economic forces driving recent reductions in *Salmonella* on U.S. chicken and discusses the implications of these reductions for U.S. poultry exports. Empirical results suggest that plant size and regulatory changes have contributed to a 50 percent reduction in *Salmonella* on chicken. These lower *Salmonella* levels will likely strengthen the U.S. bargaining position in trade negotiations and enhance the U.S. reputation in world trade but will not likely result in immediate export gains.

Keywords: U.S. poultry exports, Trade restrictions, *Salmonella*, food safety, regulation

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[1] The views expressed here are those of the authors, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

Introduction

The presence of *Salmonella* in poultry and other foods can cause diarrhea, fever, and abdominal cramping, and, if untreated, the infection can potentially cause death. Scallan et al. (2011) reported that outbreaks of food borne disease in the U.S. in 2011 led to an estimated 1,027,561 illnesses, 19,336 hospitalizations and 378 deaths, making it the second leading cause of food borne illness in the U.S.

Chicken is a major source of *Salmonella* (Scallan et al. 2011). Matthews et al. (2003) show that many countries have imposed *Salmonella* tolerances on chicken imports; these tolerances may protect the health of citizens, but they can also be import barriers and have been a subject of considerable debate in international trade.

Tolerances for *Salmonella* are reasonable if they are attainable and if they are the same for domestic producers and global exporters (Matthews et al. 2003). However, zero or near zero tolerances for *Salmonella* in chicken are viewed by many experts, such as Kramer (Feb 14, 2014), as unreasonable because *Salmonella* contamination naturally occurs in chicken flocks and a zero tolerance is costly to achieve. Nevertheless, Mathews et al. (2003) report that (1) Japan, Hong Kong, and Estonia reserve the right to test imports and reject shipments that test positive for *Salmonella*, (2) Russia and Ukraine have very low tolerances for *Salmonella*, and (3) the Czech Republic, El Salvador, Honduras, Slovakia, and Chile imposed zero tolerances on fresh chicken imports during the 1990s. The zero tolerances imposed by Czech Republic, El Salvador, Honduras, Slovakia, and Chile were particularly troublesome because those countries did not hold their own producers to the same standard.

What is a reasonable standard? Under the Pathogen Reduction and Hazard Analysis Critical Control Program (PR/HACCP) of 1996, the Food Safety and Inspection Service (FSIS) of the United States Department of Agriculture (USDA) mandated that no more than 12 out of 51 chicken carcasses could test positive for *Salmonella*. This *Salmonella* tolerance was maintained until 2011. In comparison, plants in Denmark, Sweden, and some other European countries achieve a zero or near zero tolerance (European Food Safety Authority 2010).

Kramer (2014), among others, points out that a zero tolerance for U.S. producers may be too costly of a goal, yet a tolerance of 12 out of 51 positive samples may have been too high. In 2011, FSIS cut the tolerance to 5 positive samples out of 51, suggesting that U.S. *Salmonella* levels are converging toward the more stringent standards demanded by some trading partners.

The purpose of this paper is to examine the main factors driving the reduction in *Salmonella* levels at American producers and discuss the implications of the *Salmonella* reduction for U.S. poultry exports. The empirical analysis relies on a model used in an analysis of the economic forces affecting *Salmonella* levels in ground beef in school meals (Ollinger, Guthrie, and Bovay 2014). Data were compiled from FSIS and the World Trade Atlas.

The U.S. Regulatory Environment

FSIS and its antecedent USDA agencies have regulated meat food safety since 1906 and have had an expanded role since 1968 when food safety process controls were established. These process controls include Sanitation Standard Operating Procedures (SSOPs) that required plants to (1) perform knife cleaning and other food safety tasks during operations (operating tasks), (2) equipment disassembly and cleaning and other tasks at the beginning or end of a shift (pre-operating tasks), and (3) a number of regulations, such as those dealing with maintaining facilities, cooking times and temperatures, preparation of fermented, smoked, and other processed products (see Ollinger and Mueller 2003).

FSIS further expanded its regulatory authority when it put forth the final Pathogen Reduction Hazard Analysis and Critical Control Point (PR/HACCP) rule on July 25, 1996. This regulation required meat and poultry slaughter and processing plants to develop and implement HACCP process control programs for each product. FSIS approves all HACCP plans and its inspectors verify that plants perform all tasks specified in their HACCP plan and do all SSOPs.

Under the PR/HACCP rule, FSIS mandated a *Salmonella* performance standard that requires plants that slaughter livestock or produce ground meat or poultry to meet *Salmonella* performance standards. FSIS conducts testing for *Salmonella* by randomly selecting plants for testing from a pool of plants that are not undergoing testing and evaluating their performance on *Salmonella spp.* tests. Under the PR/HACCP rule, chicken slaughter plants could have no more than 11 out of 51 carcasses test positive for *Salmonella spp*. Improvements in performance on these tests allowed FSIS to cut the *Salmonella* tolerance to 5 positive carcasses out 51 samples.

FSIS classifies poultry plants in three food safety categories based on their performance on *Salmonella* tests. If a plant meets one-half the tolerance, then it is considered to have good process control and is put in category 1. Plants that perform at a level between one half to equal to the tolerance are placed in category 2 and plants that exceed the tolerance are placed in category 3. Plants in category 1 are tested no more than once per year but at least once every two years; plants in categories 2 and 3 are tested more often than plants in category 1.

In 2008, FSIS began publishing the names of plants in category 2 and 3 on the Worldwide Web. The names of plants not published on the Web were in category 1. Publishing the names of plants with relatively weak food safety performance can encourage buyers to require their suppliers to improve performance and adversely affects the food safety reputation of suppliers assigned to either category 2 or 3. The poultry industry responded with a dramatic performance improvement on *Salmonella* tests (Figure 1). Then, in 2011, FSIS lowered the tolerance for *Salmonella* to five positive bird carcasses out of 51 samples and stopped publishing the names of plants assigned to category 2 on the Worldwide Web.

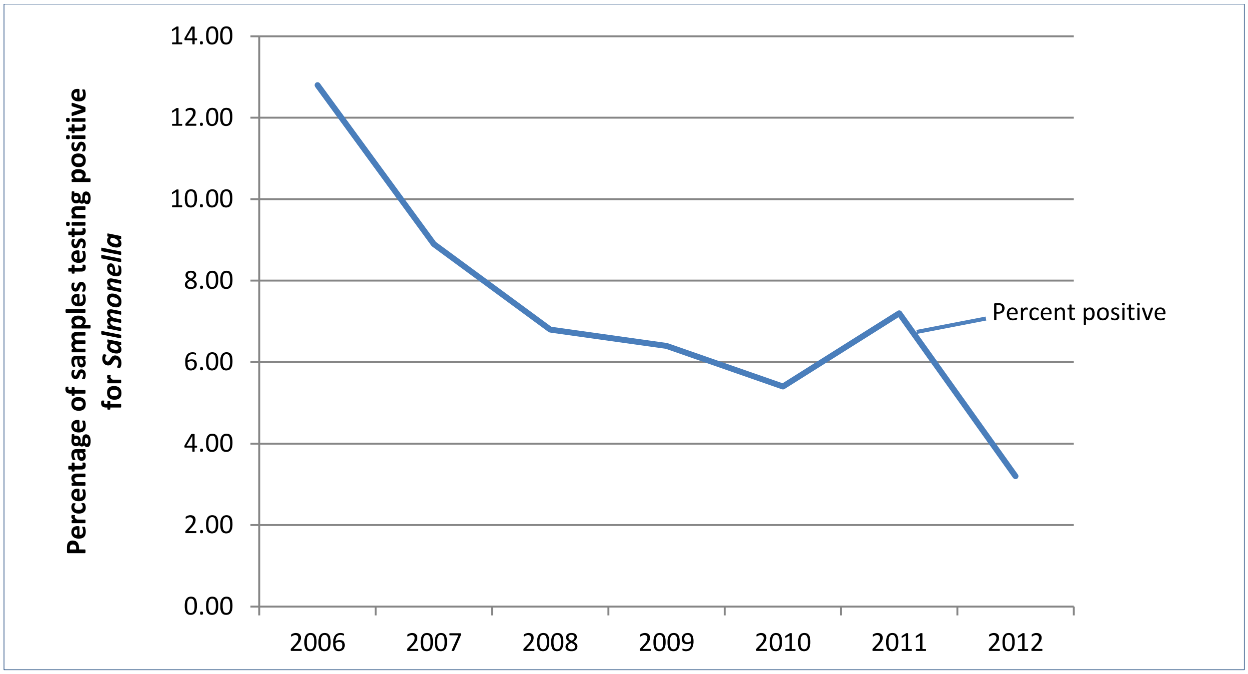

Figure 1. Percentage of Chicken Samples Testing Positive for *Salmonella* in Tests Conducted by the Food Safety Inspection Service

Source. Calculations by authors using FSIS data over 2006-2012

Economic Framework

Managers of chicken slaughter plants sell raw chicken to domestic or international buyers, depending on the profitability of each market. The costs of production are the same for all products, but the cost of food safety may vary. Products sold in the domestic markets require no extra precautions, but products sold in international markets may face very low tolerances for *Salmonella* and, in some cases, must be produced without microbial sprays and chlorine baths. These special food safety precautions raise the cost of chicken production. But, plants that are able to comply with all of these requirements at a lower cost can generate greater sales by exporting to international markets. Below, we examine a model to explain performance by chicken plants on *Salmonella spp* tests conducted by FSIS.

Muth et al. (2007), Ollinger and Moore (2008), and Ollinger, Guthrie, and Bovay (2014) examined the effectiveness of plant and food safety technologies in controlling *Salmonella* Other research has evaluated the cost of food safety regulation (Antle 2000; Ollinger and Mueller 2003; Ollinger and Moore 2009), and the impact of financial performance on *Salmonella* tests (Muth et al. 2012).

Following Ollinger, Guthrie, and Bovay (2014), we adopt a production framework in which food safety (FS) is a function of labor devoted to food safety (L), plant capital (K), plant technology (t), plant characteristics (Z), and regulatory changes made by FSIS (R):

$$(1)\qquad \mathrm{FS} = \mathrm{FS}(\mathrm{L}, \mathrm{K}, \mathrm{t}, \mathrm{Z}, \mathrm{R})$$

Equation 1 is represented econometrically as,

$$(2)\qquad FS = \alpha_0 + \sum_i \beta_i L_i + \delta K + \sum_j \rho_j t_j + \sum_k \lambda_k Z_k + \sum_l \kappa_l R_l + \xi$$

FSIS conducts *Salmonella* testing to verify a plant's food safety process control. Variables based on the results of these *Salmonella spp* tests were used as alternative measures of food safety (FS) in equation 2. Under the FSIS *Salmonella* testing program, a plant had to meet a tolerance of 12 out of 51 samples testing positive for *Salmonella* from 1996 to 2011 and 5 out of 51 samples testing positive for *Salmonella* from mid-2011 to the end of 2012.

Tolerance levels of 5 out of 51 samples testing positive for *Salmonella* is a dramatic improvement in performance on *Salmonella* tests, but it is still too high to meet the tolerance levels demanded by some export markets. A major goal of this study is to better understand the characteristics of plants best able to meet the stricter standards demanded by some importing countries. Thus, we evaluate performance on three successively stricter tolerances in which FS^* is defined as one if a plant's performance on the FSIS *Salmonella spp* test is one-fourth, one-sixth, and one-twelfth the 1996 FSIS *Salmonella spp* tolerance and zero otherwise. These are the equivalent of 3, 2, and 1 out of 51 chicken samples testing positive for *Salmonella*.

Plants meet a tolerance or they do not meet the tolerance. Thus, we use a probit regression (equation 3).

$$(3)\qquad FS^* = \alpha_0 + \sum \beta_i L_i + \delta K + \sum_j \rho_j t_j + \sum_k \lambda_k Z + \omega R + \xi$$

$$FS^* = 1 \quad if \quad FS \le tolerance$$

$$FS^* = 0 \quad if \quad FS > tolerance$$

FSIS requires all meat and poultry plants to perform SSOPs and tasks needed to maintain a HACCP process control programs. SSOPs and HACCP tasks are monitored by FSIS inspectors that record whether a task was performed and in compliance with FSIS standards. A high number of noncompliant ratings (noncompliances) imply that less effort is devoted to food safety process control; a low number of noncompliances suggest that more effort (labor) is devoted to food safety process control.

There are pre-operational and operational SSOP tasks. Pre-operational SSOP tasks are tasks at the end or beginning of the production day; operating tasks are duties performed during production. HACCP tasks are process control tasks that are specified in the plant's HACCP plan. Ollinger and Moore (2008) found that better performance of SSOPs and HACCP tasks improved performance on *Salmonella* tests in ground beef plants.

A plant's capital equipment is captured by plant size (the number of chickens slaughtered). Muth et al. (2007) and Ollinger and Moore (2008) found that plant size had a positive impact on food safety performance in the cattle, hog, and chicken slaughter industries.

There are several plant technology variables. Muth et al. (2007) found that plant age had a significant and negative impact on *Salmonella* levels in hog and chicken slaughter and further-processing plants. Other technology variables account for the variety of animals slaughtered and whether the plant did further processing. Both operations may raise food safety costs by making the plant more complicated.

It is also necessary to identify plants that are owned by firms that own other plants because these plants may benefit from the parent company's ability to share food safety practices across units. Additionally, it is important to account for the geographic region since different types of birds with different market outlets may be processed in different regions. Finally, there is a regulatory change variable to account for the change in FSIS tolerances in 2011.

Data and Variables

The data are a pooled dataset of all chicken slaughter plants whose products were tested for *Salmonella* by FSIS over 2009-2012. After dropping observations with missing values and several very large and very small plants, our dataset includes data records for 462 chicken slaughter plants. These plants may have lucrative contracts with large restaurants and other large commercial customers that impose their own food safety standards. These private standards may be stricter than those required by FSIS. The data also include plants that sell to wholesalers, retailers, and others with no specific food safety requirements.

Salmonella data come from files at FSIS. Each year FSIS randomly selects plants for *Salmonella* testing. Selection is based on the volume of production. Not all plants are tested each year, but there was an average of about 120 plants tested each year over 2009-2012.

The SSOP and HACCP compliance data and some plant characteristics come from FSIS administrative data and are available for all plants inspected by FSIS every year. The FSIS administrative data include the type and number of animals slaughtered, types of meat or poultry processed, name and address information, and when a plant began operation.

Dunn and Bradstreet, a widely-used database of plants and firms, was used to identify business activities of the plant and whether the plant is part of firm that owns more than one plant. The Dunn and Bradstreet data include a wide array of business and financial information, including sales, square footage of the plant, major industry category, line of business, US 1987 SIC 1, US 1987 SIC 2, and US 1987 SIC 3, a primary activity code, and indicators for being a subsidiary, manufacturer, small business, public/private firm and others.

Estimation Procedures

The data are a pooled dataset with a binary choice dependent variable. Pooled data include temporal and cross-sectional components, making it necessary to consider possible autocorrelation errors and heteroskedasticity. Beck, Katz, and Tucker (1998) obtain accurate standard errors using duration dependence techniques for pooled data with a binary dependent variable that extends over 30 periods and has little or no change in the dependent variable. Our data are also panel data with a binary dependent variable, but the maximum duration of the temporal component is 4 periods, making a duration dependence model inappropriate and a probit model the technique of choice.

Our data has a time series component, raising the possibility of autocorrelated error. Beck, Katz, and Tucker (1998) argue that autocorrelation cannot be detected in probit models and a review of the econometric literature suggests this still is the case. Beck and Katz (1997) assert that the Huber sandwich estimator (Huber 1967) corrects most of the auto-correlated error in the standard error if there is autocorrelation and does not affect results if there is no autocorrelation. Thus, we use a Huber sandwich to adjust for autocorrelation.

We also tested our model for multiplicative heteroskedasticity in plant size since plant size varies substantially across plants. However, there was no need to make an adjustment because a log-likelihood test does not reject the null hypothesis that the model is homoscedastic.

Empirical Results from the Model

Table 1 gives the variable definitions and names and their mean values. The mean of chickens slaughtered equaled about 12.8 million chickens per year. The number slaughtered varied from about 10,000 to 120 million per year. The mean plant age is 17.6 years and varied from 1 to 93 years old. The data also shows that about one half of all plants had food safety performance levels equal to one-sixth the tolerance for Salmonella in 2008, i.e. no more than 2 out of 51 samples testing positive for *Salmonella*. The mean percentage of samples testing positive was about 5.5 percent (equivalent to 2.8 samples per 51 samples).

Figures 1 and 2 show the trends in performance on *Salmonella* tests over 2006-2012. Figure 1 shows that the percent of samples testing positive for *Salmonella* dropped from around 13 percent in 2006 (6.6 per 51 samples) to about 3 percent in 2012 (1.5 per 51 samples). Figure 2 shows that by 2012 about 85 percent of the chicken plants reached levels of performance on *Salmonella* tests equal to one-fourth the tolerance that existed prior to 2011 and that no samples tested positive for *Salmonella* in about 35 percent of all plants. By contrast, less than 30 percent of chicken slaughter plants had a level of performance on *Salmonella* tests equal to one-fourth the tolerance that existed prior to 2011 and less than 10 percent of chicken slaughter plants had no samples testing positive for *Salmonella* in 2006. These recent changes demonstrate a level of performance on *Salmonella* tests that is compatible with the strict standards mandated by many U.S. trading partners. Moreover, about 35 percent of all plants could meet the zero tolerance levels imposed by some countries.

Table 1. Mean Values of Selected Economic Variables of Chicken Slaughter Plants

Variable	Variable Label	Definition	Mean
-	Percent positive *Salmonella spp* Samples	Share of samples testing positive for *Salmonella spp* in FSIS testing	0.056
FS	One-Fourth *Salmonella spp* Standard	One if share of samples testing positive for *Salmonella* less than one-third FSIS standard, else zero	0.677
FS	One-Sixth *Salmonella spp* Standard	One if share of samples testing positive for *Salmonella* less than one-sixth FSIS standard, else zero	0.513
FS	One-Twelfth *Salmonella spp* Standard	One if share of samples testing positive for *Salmonella* is less than one-twelfth FSIS standard, else zero.	0.328
L	PCENT_HACCP_PASS	Percent of HACCP tasks not in compliance with HACCP plan	0.983
L	PCENT_SSOP_P_PASS	Percent of pre-operational SSOPs complying with standard	0.891
L	PCENT_SSOP_O_PASS	Percent of pre-operational SSOPs complying with standard	0.937
K	Chicken	Millions of chickens slaughtered per year	12.800
T	Plant age	Current year minus year poultry grant issued, else zero	17.600
T	Multi-species	One if slaughter more than one animals species, else zero	0.225
T	Share other animals slaughtered	Number of animals other than chickens slaughtered as a share of all animals slaughtered	0.009
T	Does further processing	One if further processes some meat, else zero	0.120
Z	Multiplant firm	One if plant is part of a multi-plant firm, else zero	0.116
Z	Atlantic	One if in Delaware, Maryland, Virginia, West Virginia	0.081
Z	Midwest	One if in Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Ohio, Wisconsin, else zero.	0.063
Z	Northeast	One if in N. Jersey, N. York, Pennsylvania, Vermont, else zero	0.066
Z	Southeast	One if in Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, N. Carolina, S. Carolina, else zero	0.450
Z	West	One if in California, Colorado, Hawaii, Washington, else zero	0.044
Z	West South	One if in Arkansas, Missouri, Oklahoma, Tennessee, Texas, else zero	0.225
R	Year_2011_12	One if started Salmonella testing after July 1, 2011, zero otherwise	0.345
	Observations		464.000

Source. Estimates by Authors using FSIS Data.

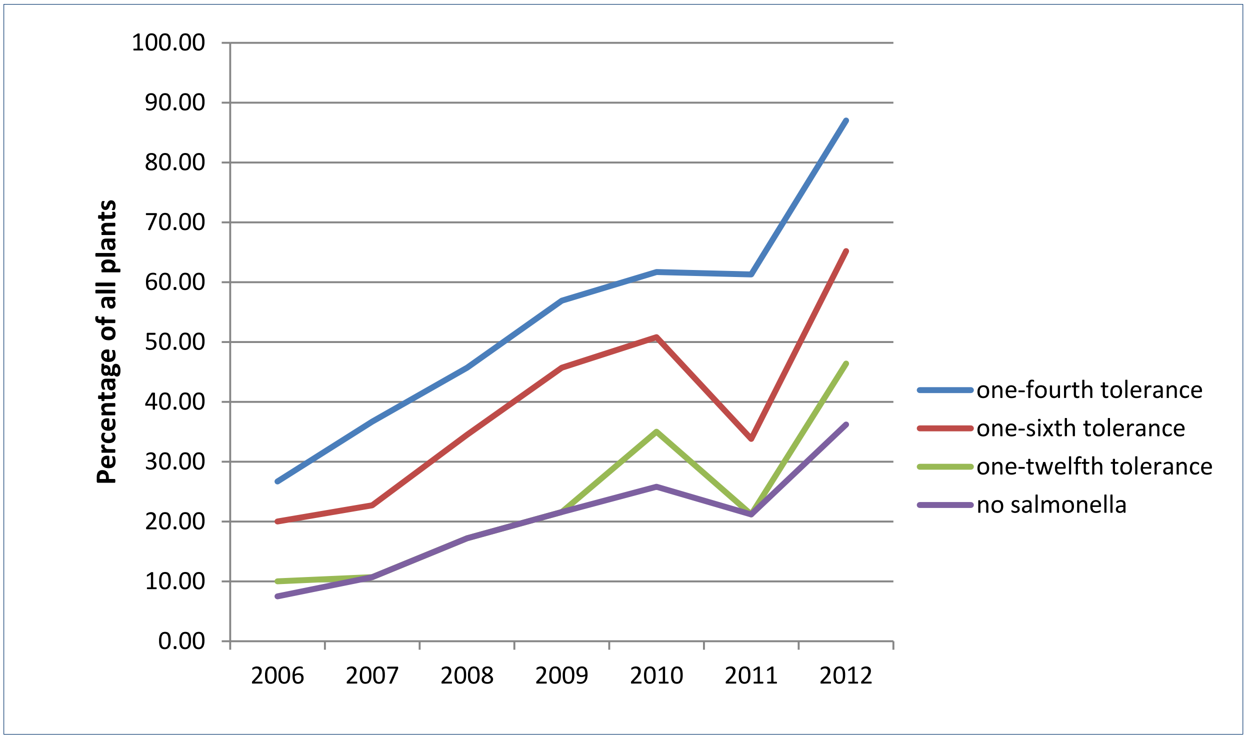

Figure 2. Chicken Plant Performance on *Salmonella* Tests Conducted by the Food Safety and Inspection Service

Note. The FSIS tolerance was 12 out of 51 samples could test positive for Salmonella from 2006-2011 and was assumed to remain the same for 2012.
Source. Authors estimates based on FSIS data.

Table 2 gives the results of three versions of our model in which the dependent variable is defined as one-fourth, one-sixth, and one-twelfth of the initial *Salmonella* tolerance. This is identical to saying that 3, 2, or 1 sample tested positive for *Salmonella* out of 51 samples taken.

The number of chickens slaughtered, whether the plant further processed chickens, and the food safety regulation of 2011 had statistically significant and positive effect on food safety performance. Model results suggest that, compared to other plants, further processors were about 17 percent more likely to have a food safety performance equal to one-fourth the FSIS *Salmonella* tolerance, 15 percent more likely to have a food safety performance equal to one-sixth the FSIS *Salmonella* tolerance, but no more likely to have a one-twelfth the *Salmonella* tolerance. Similarly, a ten percent change in the log of chickens leads to a 0.6 percent improvement in performance on the one-sixth FSIS tolerance for samples testing positive for *Salmonella* and a 0.5 percent improvement in performance on the one-twelfth FSIS tolerance for samples testing positive for *Salmonella*.

The regulatory change of mid-2011 had a major impact on food safety performance. Plants responded by improving their performance on tests of the number of samples testing positive for *Salmonella* at one-fourth, one-sixth, and one-twelfth of the FSIS tolerance, by 29.6, 17.6 and 18.1 percent, respectively.

Table 2. Marginal Effects of Food Safety Performance of U.S. Chicken Slaughter Plants

Variable	One-Fourth Tolerance for *Salmonella spp*[1]		One-Sixth Tolerance for *Salmonella spp*[1]		One-Twelfth Tolerance for *Salmonella spp*[1]	
HACCP_PASS0,	1.736		1.423		1.170	
	(1.352)		(1.419)		(1.425)	
SSOP_P_PASS0	0.156		-0.129		-0.242	
	(0.296)		(0.298)		(0.290)	
SSOP_O_PASS0	0.265		0.537		0.888	*
	(0.505)		(0.517)		(0.554)	
Log (Chickens)	0.009		0.061	**	0.052	**
	(0.031)		(0.027)		(0.020)	
Plant age	-0.0019		-0.0025	*	-0.0011	
	(0.0015)		(0.0015)		(0.001)	
Multi-species	-0.102		0.023		0.032	
	(0.078)		(0.080)		(0.083)	
Share other animals slaughtered	0.088	*	-0.556		0.007	
	(0.518)		(1.065)		(0.635)	
Further processing	0.170	***	0.154	**	0.061	
	(0.065)		(0.069)		(0.072)	
Multiplant firm	0.092		0.049		-0.046	
	(0.081)		(0.094)		(0.072)	
Atlantic	-0.023		0.087		0.092	
	(0.144)		(0.130)		(0.140)	
Midwest	-0.423	***	-0.171		-0.136	
	(0.132)		(0.145)		(0.104)	
Northeast	-0.403	***	-0.193		-0.225	**
	(0.136)		(0.181)		(0.097)	
Southeast	-0.097		0.039		0.047	
	(0.086)		(0.095)		(0.088)	
West	-0.128		0.140		0.193	
	(0.182)		(0.159)		(0.153)	
Year_2011_12	0.296	***	0.176	**	0.181	***
	(0.051)		(0.071)		(0.067)	
X^2	43.4	***	42.8	***	47.8	***
Observations	462		462		462	
X^2 of Likelihood of Heteroskedasticity	0.00		0.61		0.05	

Note. * Denotes 0.10 significance level, ** 0.05 level, and *** 0.01 significance level. Instead of the line above.
[1] Tolerances were reduced from 12 out of 51 samples could test positive for before the middle of 2011 to 5 out of 51 samples could test positive for *Salmonella* after the middle of 2011.

We do not know the food safety technology used to improve performance on *Salmonella* tests because this measure is a performance standard in which FSIS established a tolerance (a maximum of five positive test results per 51 samples) that plants can meet in any manner they choose. Plants in the U.S. frequently use antimicrobial sprays because this is effective and approved for use in the U.S. (Laury et al. 2009). EU countries and some others ban imports of products processed with anti-bacterial products, making this a trade issue.

Do *Salmonella* Reductions Matter for U.S. Exports?

Matthews et al. (2003) point out that the presence of *Salmonella* on poultry is a justified reason for restricting trade if it is excessive but it often used as way to prevent imports. These motivations make it important to define what an excessive level of *Salmonella* is. Moliterno-Duarte et al. (2009) found a 9.6 percent prevalence rate in Brazilian chicken and report that other researchers found levels, ranging from 5.9 percent to 42 percent in chicken carcasses in other Brazilian states. Moliterno-Duarte (2009) also reported that other researchers found *Salmonella* levels of 13% in Poland (Mikolajczyk 2002), 29.3% in Belgium (Uyttendaele et al. 1998), 29.7% in UK (Plummer et al. 1995), and 35.8% in Spain (Dominguez et al. 2002). More recently, The European Union Food Safety Authority (2010) reported that *Salmonella* levels in European countries varied from 0.0 to 26.6 percent.

Given the 66 percent reduction in *Salmonella* levels in U.S. broilers since 2006 (Figure 1) and the relatively high levels of *Salmonella* detected in poultry in other countries (preceding discussion), it would seem that U.S. exporters are well-positioned for growth in export markets**.** However, exports have remained relatively steady since 2010 after a sharp increase in sales from 1990 to 2010. Table 3 shows that U.S. poultry exports rose about 400 percent between 1990 and 2000 and another 25 percent from 2000 to 2010. Most of the growth in the early years was due to exports to major trading partners, including Russia, Hong Kong, Mexico, Canada, and Central-EU-13. That growth leveled off after 2000, but exports to the rest of the world then expanded until about 2010. Since 2010, U.S. poultry shipments have been rising to Mexico and China, but these gains have been offset by declining sales to Russia and Central-EU-13 (Table 3). Note, the European Union had a major expansion in membership when it reached 25 members in 2004 after 10 new countries joined. Currently, there are 28 member countries.

Poultry exports to Europe have been limited by food safety regulations. Changes in exports to the Central-EU-13 countries, which joined the EU after 2004, show the effect of these requirements. Exports to the Central-EU-13 countries dropped from 278,000 metric tons in 2000 to about 71,000 in 2013 (Table 3). Similarly, EU imports of US poultry dropped from 32,000 tons in 1999 to about 125 tons in 2013 (World Atlas). Note, the difference between EU imports and U.S. exports may be due to transshipments (Johnson 2012). For example, 90 percent of U.S. exports to the EU went to Lithuania—one of the smallest countries in Europe.

Table 3. U.S. Exports of Poultry Meat in Metric Tons, 1990-2013

Country	**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**
Mexico	51.7	149.0	275.9	413.6	565.2	622.9	731.7	818.2
China	2.6	40.7	81.8	166.7	137.1	137.1	286.3	324.4
Russia	-	696.2	691.5	784.7	321.8	212.6	267.7	274.6
Hong Kong	85.4	466.5	675.4	127.7	446.7	557.6	302.4	175.2
Canada	39.3	45.7	90.7	97.9	125.0	133.9	159.6	150.5
Taiwan	0.3	2.2	24.1	88.2	104.9	103.4	141.6	132.9
EU-28	38.6	165.3	329.4	226.1	161.0	140.0	106.5	77.7
EU-15	26.5	38.0	51.1	17.7	11.2	10.6	7.8	7.1
Central-EU-13[1]	12.1	127.3	278.3	208.3	149.9	129.4	98.8	70.6
Philippines	0.2	0.4	15.6	12.1	52.7	66.2	79.1	73.7
Major Partners	217.9	1,566.1	2,184.4	1,917.0	1,914.6	1,973.6	2,075.0	2,027.2
Rest of World	353.1	383.2	631.4	782.3	1,623.7	1,767.4	1,856.2	1,796.7
World Total	571.1	1,949.3	2,815.8	2,752.3	3,538.3	3,741.5	3,931.2	3,868.9

Note. Central EU-13 is countries that joined the EU after 2004
Source. World Trade Atlas, 2014

The EU now maintains a zero tolerance for *Salmonella.* All European countries do not meet this zero tolerance (European Union Food Safety Authority 2010), while some U.S. plants are producing broilers with nondetectable levels of *Salmonella,* suggesting potential for U.S. exports to the EU. Exports by these U.S. companies, however, appear unlikely because *Salmonella* reductions were likely achieved with the use of antimicrobial washes (Laury et al. 2009) and the EU limits the use of antibiotics, vaccines and antimicrobial washes.

Access to Russian markets has been denied several times when Russian authorities claimed exporters violated the Russian *Salmonella* standard. A major dispute in 1995 occurred when Russia threatened to embargo poultry imports from the U.S. unless the U.S. exporters could certify their poultry was *Salmonella*-free. That disagreement was quickly resolved, but another interruption in 2002 had more serious consequences, leading to a 35 percent decline in U.S. exports to Russia (Orden et al. 2002, 162).

The most serious poultry trade breach with Russia occurred in 2010. At that time, Russia was the largest export market for U.S. poultry, averaging more than 786,000 tons (26 percent of all exports) over 2000-2009, which was about equal to Mexico (11.7 percent), China (10.8 percent), and Canada (3.4 percent) combined. Then, U.S. shipments dropped by nearly half to 322,000 tons in 2010 after Russia abruptly banned U.S. imports. National Journal (Koren 2014) reported that Russian authorities justified the restriction over concern of the use of chlorine solution as a means of controlling *Salmonella* in chicken. U.S. chicken plants had been using chlorine baths for many years prior to the ban and Russia accepted the product. National Journal noted that this trade restriction, like earlier interruptions, coincided with rising political tensions between the U.S. and Russia. After some negotiations, U.S. chicken exports to Russia resumed.

The dramatic drop in U.S. poultry meat exports to Russia illustrated in Figure 3, shows that exports dropped from 80 million kg in October 2009 to about zero in February through August 2010 and then a rebounded to previous levels. Russia was able to partially offset the sharp drop in U.S. poultry shipments with increased purchases from Brazil and Germany (Table 4). It is ironic to note that, during this time period, U.S. poultry meat prices, on average, remained below the World average price and always below that of Brazil. Moreover, U.S. *Salmonella* levels were below those for Brazil, as reported by Moliterno-Duarte et al. (2009).

Table 4. Russian Poultry Meat Imports, 2009-2013

	2009	2010	2011	2012	2013
Million Kg					
Total Volume	948	650	404	470	528
United States	700	295	240	265	266
Brazil	69	143	71	70	54
France	49	32	28	30	18
Germany	92	102	30	6	2
Average price US Dollars/Kg					
World Average	1.12	1.33	1.42	1.51	1.61
United States	1.05	1.15	1.28	1.28	1.27
Brazil	1.91	1.81	2.12	2.24	2.72
France	1.21	1.28	1.12	1.18	1.25
Germany	1.06	1.22	1.06	1.73	1.78

Source. World Trade Atlas 2014

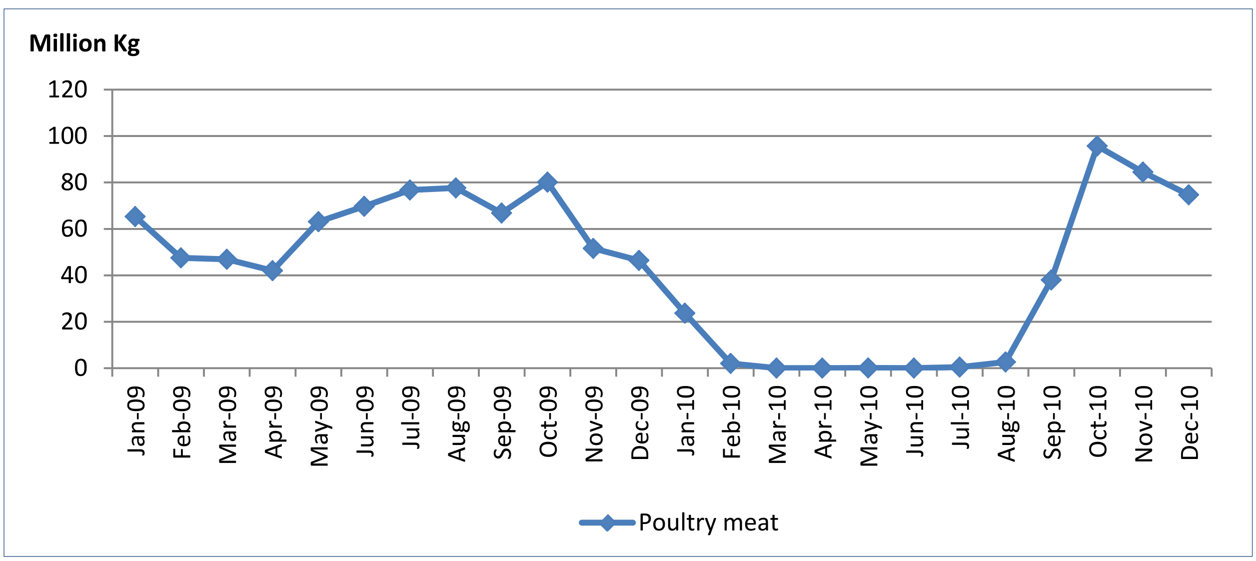

Figure 3. U.S. Poultry Exports to Russia, Jan. 2009 – Dec. 2010.
Source. World Trade Atlas 2014

Conclusion

This paper examined some of the economic forces encouraging lower *Salmonella* levels in U.S. poultry production and discussed the importance of lower *Salmonella* for encouraging exports to global markets. The paper showed that larger poultry plant size, whether a plant further processed poultry, and lower tolerances for *Salmonella* mandated by FSIS resulted in much lower levels of *Salmonella* in U.S. poultry. This reduction in *Salmonella* would seem to encourage poultry exports. Yet, as *Salmonella* levels dropped over the 2008-2012 period, growth in U.S. poultry exports stagnated as Russia and the EU reduced their poultry purchases. Neither were satisfied with U.S. reductions in *Salmonella* in poultry -- Russia insisted on a zero-*Salmonella* level and the EU-28 had concerns about *Salmonella*, the use of antibiotics in animal husbandry, and the use of anti-microbial washes in chicken processing.

The decline in exports to Russia and the EU-28 over 2008-2012 was offset by increases in exports to two NAFTA trade partners – Mexico and Canada. Herein may lay the benefit of reductions in *Salmonella* for chicken exporters. Much trade occurs through trade agreements with individual or groups of countries, such as Mexico and Canada. These trade agreements often encompass a broad array of products including agricultural outputs and cover a number of issues, including food safety. Reductions in *Salmonella* levels provide U.S. exporters a strong reputation for food safety, giving U.S. trade negotiators a better bargaining position and more flexibility in reaching valuable trade agreements that can benefit the U.S. poultry industry. All other things being equal, including prices, importing countries will most likely buy products that are less likely to have *Salmonella* in order to protect the health and safety of their citizens.

There are three important implications of this research. First, large poultry processing plants are best able to meet the very strict tolerances for *Salmonella* demanded by international markets. Second, FSIS regulations helped reduce the *Salmonella* levels of U.S. poultry plants, making poultry from all U.S. poultry plants more competitive on the basis of food safety in international markets. As food safety technology improves, further reductions in *Salmonella* tolerances is possible, enabling greater U.S. competitiveness in international markets. Third, reductions in *Salmonella* may have little direct immediate impact on poultry exports, but will likely provide a stronger U.S. bargaining position in global markets and trade negotiations.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

What's Driving U.S. Broiler Farm Profitability?[1]

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Abstract

Using USDA's ARMS data for 2003-2011 and the DuPont expansion financial model, we determine the extent and location of U.S. broiler farms and estimate the drivers of farm profitability, asset turnover, solvency, and return on equity. We find that farm size, diversification, and broiler housing vintage are the major drivers of farm financial performance, so these factors will likely have the greatest impact on U.S. broiler production in an increasingly competitive broiler trade market. Furthermore, region, farmer age, and off-farm employment are additional farm financial performance drivers that have implications for international competitiveness.

Keywords: DuPont model, profitability, solvency, asset efficiency, broilers

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[1] The views expressed are those of the authors and do not necessarily represent the views or policies of the USDA.

Introduction

The broiler industry plays a significant role in the economy of a number of states in the U.S., particularly those located in the South. In 2012, almost 33,000 U.S. farms sold nearly 8.5 billion broilers and other meat-type chickens (USDA Census of Agriculture 2014). This resulted in nearly 37 billion pounds of product being produced on a ready-to-cook basis, of which approximately 20% was exported and the remainder consumed in the U.S. at a consumption rate of 95 pounds per capita (USDA-NASS 2013). Over 2004-2013, total broiler and other chicken meat produced increased from 34.2 billion pounds to 37.9 billion pounds, of which exports increased from 5.0 billion pounds to 7.5 billion pounds, and domestic consumption remained relatively stable, moving from 29.1 billion pounds to 30.5 billion pounds (USDA-NASS 2013). These figures suggest that the export market has been responsible for the marketing of the majority of the increased production. The importance of trade in U.S. broiler production suggests that the industry must continue to remain competitive in the world broiler market, with cost of production and farm financial performance continuing to be of importance domestically. This paper addresses the drivers of financial performance of U.S. broiler farms, with implications for broiler trade.

Broiler production is concentrated in a group of states in the U.S. (Figure 1) primarily in the South, but also including significant production in California, Delaware and Pennsylvania. The top broiler states are Georgia, Arkansas, Alabama, Mississippi, and North Carolina.

Nearly all U.S. broiler growers operate under production contracts with large, quasi-vertically integrated firms that produce feed and handle bird processing (Knoeber 1989; Rogers 2002; MacDonald 2008). Figure 2 shows the organization of the U.S. broiler industry. A significant open cash market for broilers has not existed since the 1950s. Under production contracts, broiler growers do not own the birds; rather they provide the broiler grow-out house, labor, and utilities required to raise the chicks. The grow-out house and associated equipment can require a significant investment of $300,000 or more. The house is equipped, by agreement with the contractor (or integrator), with all necessary heating, cooling, feeding, and watering systems. The grower provides the labor and clean litter needed for growing the birds and disposes of the used litter. The contractor supplies the chicks, feed, veterinary services, and transportation to the processing plant when the broilers are fully grown. The birds and feed are owned by the contractor who contracts with the grower to feed the birds to market weight. A typical broiler production contract involves a tournament in which growers are paid by the contractor on the basis of their productivity relative to the productivity of the other growers in the same group (Knoeber 1989). Taylor (2004) provides a critical review of the "fairness" of production contracts. The integrator generally owns the hatchery, feed mills, and slaughter and further processing plants. The breeding segment is generally either owned by the integrator or contracted with breeding companies (MacDonald 2008).

The structure of this industry has led to relatively low costs per pound of broiler meat produced, making the U.S. market particularly competitive on the world broiler market. The resultant high productivity led to greater exports (MacDonald 2008). However, low-cost countries that have emerged as broiler producers in recent years, such as Brazil, China, and Thailand, are potential threats to the U.S. broiler export market (Constance 2008). The U.S. broiler model has been exported to a number of countries throughout the world. Various U.S. companies such as Tyson Foods, Cargill, Inc., and Pilgrim's Pride have invested in countries in Asia, South America, and Mexico with operations there (Constance 2008).

The U.S. broiler industry is currently undergoing retrenchment. While the industry's organization contributed to commercial success for most of the last two decades, the industry today faces challenges in the form of volatile feed costs, now in a profitable range with a broiler to feed ratio of over 5 after almost two years below 5 (Day 2015). Moreover, smaller farms tend to have significantly older broiler houses, leading to lower operator returns per broiler and greater reliance on off-farm income. Hence, the industry is shifting toward larger operations where household income is more closely tied to the broiler enterprise. In addition, two recent major bankruptcies of integrators (Day 2015) have resulted in a more global business model for integrators. (See *Feedstuffs* July, 2014, on the divestiture of Tyson holdings in Mexico and *Feedstuffs*, September, 2014, for the trade outlook for broiler meat). At the same time, per capita domestic consumption appears to be strengthening in recent years with projected 2015 consumption close to the historic high of about 86 pounds per capita in 2006 (The National Chicken Council 2015).

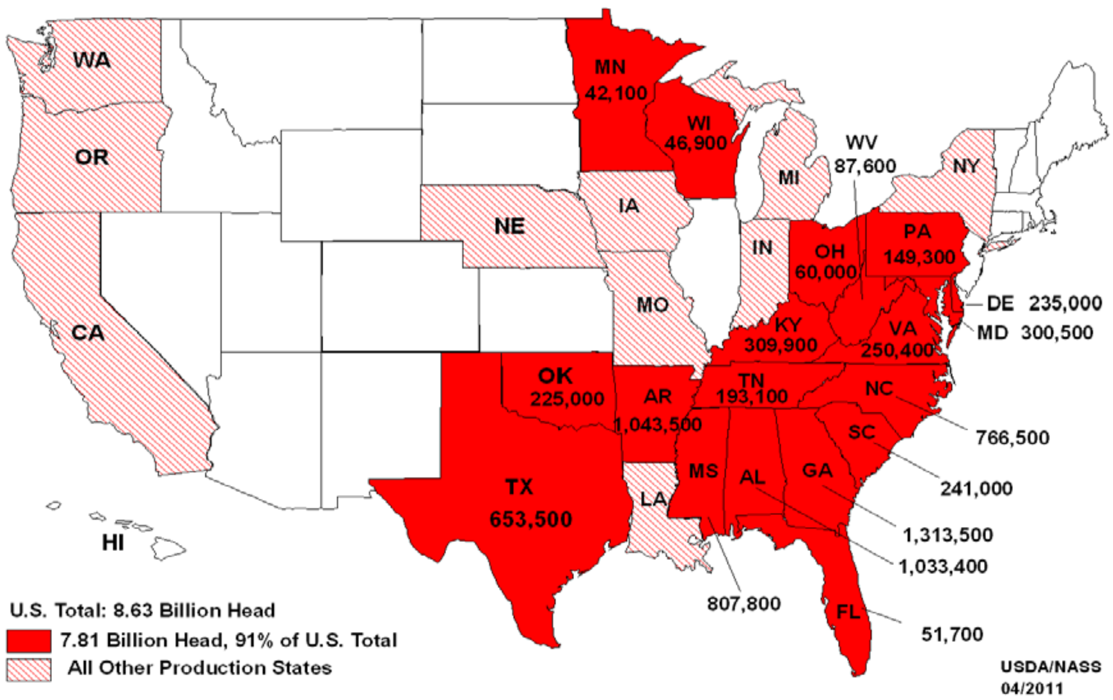

Figure 1. Broiler production by state number produced, thousand, 2010.
Source. USDA, National Agricultural Statistics Service, Washington DC, 2011.

Factors influencing trade for broiler meat have generally been similar to drivers for other products. Davis et al. (2014) show that broiler trade was affected by several drivers: exporter and importer GDPs and population, distance between countries, whether countries have common borders and/or languages, whether countries are part of the North American Free Trade Agreement or the European Union, and exchange rate volatility. Another trade determinant has been cost of production. Golz and Woo (1991) estimated, for example, that if Canada and Mexico reduced their production costs by 10%, they would import less broiler meat from the U.S., and if they reduced their production costs by 20%, they would become net exporters to the U.S. Clearly, production costs and hence profitability are significant trade flow determinants and relatively small changes in the cost structure can alter broiler trade. Factors that can alter competitiveness and thus trade in the relative short run but with potential long-term impacts can include feed costs, labor costs, demand, disease outbreaks such as avian influenza, others. Determination of the drivers of financial success (profitability, solvency, and asset efficiency) in U.S. broiler production is useful in determining competitiveness in broiler trade.

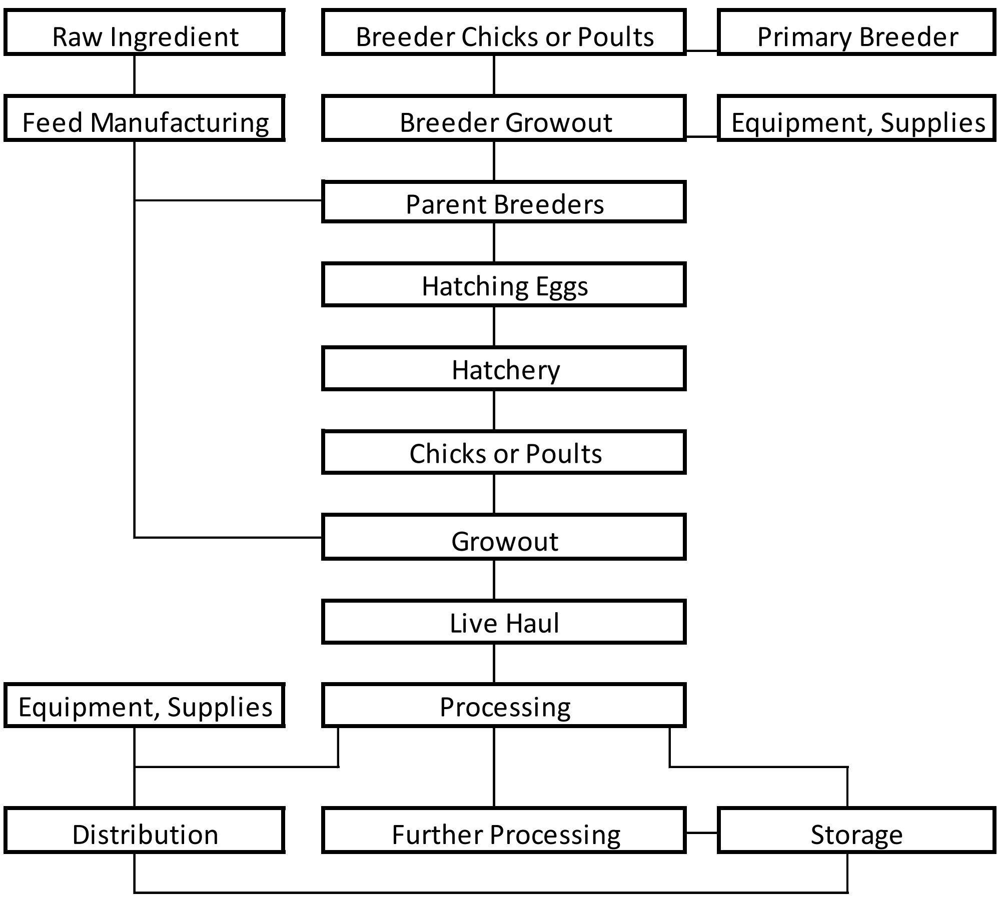

Figure 2. Structure of the U.S. Broiler Industry
Source. Poultry Science and Technology Guide Extension Poultry Science, North Carolina State University, Raleigh, North Carolina, 2011.

A country's agricultural competitiveness in the global market can depend on a number of factors, which are considered in this study. For example, farm size can impact competitiveness. MacDonald (2008) shows the cost advantages that are associated with large-scale broiler production. Furthermore, production technology is hypothesized to impact competitiveness. Broiler houses built since 1996 have the capacity for greater control over the environment (climate controls), and therefore may further impact the financial performance of the broiler operation. Other issues such as farm diversification, off-farm work, and management may also impact farm financial performance and, thus, global competitiveness and trade.

The objective of this study is to examine the drivers of financial success in U.S. broiler production. Specifically, we examine factors influencing broiler farm profitability, decomposing it into four components including net return on assets, asset efficiency, solvency, and net return on equity. We analyze the USDA's Agricultural Resource Management Survey (ARMS) 2003-2011 Phase III data for broiler farms to estimate a DuPont expansion model. We discuss the implications of this analysis for U.S. broiler trade.

The DuPont Expansion Model

We use the DuPont expansion model to analyze the economic and financial performance of U.S. broiler farms. The DuPont Expansion (also commonly known as the DuPont identity, DuPont equation, DuPont model, or the DuPont method) is a method that breaks return on equity into three parts: profitability, operating efficiency, and financial leverage. Mishra et al. (2012) attribute the original DuPont model to F. Donaldson Brown in 1918, who showed that return on assets was the product of two common financial ratios, one for profitability and the other for efficiency. This later evolved into the three-part equation used today. The name originated from the DuPont Corporation, which started using this formula in the 1920s. Based on these three performance measures, a farm can increase its return on equity by maintaining a high profit margin, increasing asset turnover, or leveraging assets more efficiently. This approach helps simplify the farm financial performance analysis and improve decision making concerning operations and finance (Moss 2013). The DuPont expansion model has been widely used for firm analysis in corporate finance as well as by university extension personnel for farm business analysis.

The DuPont expansion focuses primarily on the return on owner's equity, *R/E*, where *R* is net return and, for farm analysis, *E* is farm equity. Net return is defined as *R* = *S* – *C*, where *S* represents agricultural sales and *C* represents production costs. Collins (1985) introduced a variant of the DuPont formulation which has been used in agricultural finance applications (Melvin et al. 2004, Mishra et al. 2012, Moss 2013). The DuPont identity decomposes return on equity into profitability, asset turnover, and leveraging decisions as: *Return on Equity* = *Operating Profit Margin* × *Asset Turnover* × *Solvency*. The equation used to analyze the relationship between the rate of return on equity, asset efficiency, profitability, and solvency, is shown as (Mishra et al. 2009):

$$(1) \qquad \frac{\mathrm{R}}{\mathrm{E}} = \frac{\mathrm{S\text{-}C}}{\mathrm{S}} * \frac{\mathrm{S}}{\mathrm{A}} * \frac{\mathrm{A}}{\mathrm{E}} \frac{\mathrm{R}}{\mathrm{E}} = \frac{\mathrm{S\text{-}C}}{\mathrm{S}} * \frac{\mathrm{S}}{\mathrm{A}} * \frac{\mathrm{A}}{\mathrm{E}},$$

where *A* is the value of farm assets. Thus, with the DuPont expansion, return on equity is the product of farm profitability using the operating profit margin ratio $\left(\frac{\mathrm{R}}{\mathrm{S}}\right)\left(\frac{\mathrm{R}}{\mathrm{S}}\right)$, farm asset efficiency using the asset turnover ratio $\left(\frac{S}{A}\right)\left(\frac{S}{A}\right)$, and farm solvency (or in our case inverse solvency) using the inverse of the equity/asset ratio $\left(\frac{A}{E}\right)\left(\frac{A}{E}\right)$.

In cases where the farm is debt-free, the rate of return on equity equals the farm's rate of return on assets $\left(\frac{R}{A}\right)\left(\frac{R}{A}\right)$. However, if there is interest to be paid on debt, it must be subtracted from net farm income *R*. Furthermore, in these cases when the farm has debt, assets > equity. As measures of profitability, higher rates of return on equity and higher operating profit margin ratios are preferred.

Asset efficiency measures how quickly the farm's gross revenue covers the capital invested in farm assets. In other words, with a farm asset ratio of 0.25, it would take four years for the farm to realize gross revenue that would cover the investment in assets. A higher asset turnover ratio is desirable since this indicates shorter time to cover investment costs.

Solvency provides a measure of whether farm liabilities can be covered by selling farm assets. The equity/asset ratio is a measure of solvency that indicates owner equity capital as a portion of total farm assets. In the DuPont expansion as we present, a measure of inverse solvency is analyzed. More information regarding these measures of profitability, asset efficiency, and solvency can be found in the literature (Kay et al. 2012).

Previous authors (Mishra et al. 2009) show that the DuPont expansion is linear in logs, as in (2):

$$(2) \qquad \ln\left(\frac{R}{E}\right) = \ln\left(\frac{R}{S}\right) + \ln\left(\frac{S}{A}\right) + \ln\left(\frac{A}{E}\right) \ln\left(\frac{R}{E}\right) = \ln\left(\frac{R}{S}\right) + \ln\left(\frac{S}{A}\right) + \ln\left(\frac{A}{E}\right)$$

In accordance with this relationship, determinants of farm financial performance can be analyzed using seemingly unrelated regression (SUR) where a separate equation is estimated for the farm's return on equity, operating profit margin ratio, asset turnover ratio, and equity/asset ratio. These measures, thus, serve as the dependent variables in a system that takes into consideration the correlation of the error terms. SUR was also deemed appropriate since the Breusch-Pagan test showed correlation of the cross-equation error terms. Because $\ln\left(\frac{R}{E}\right)\ln\left(\frac{R}{E}\right)$ is the sum of $\ln\left(\frac{R}{S}\right), \ln\left(\frac{S}{A}\right), \ln\left(\frac{R}{S}\right), \ln\left(\frac{S}{A}\right)$, and $\ln\left(\frac{A}{E}\right)$ $\ln\left(\frac{A}{E}\right)$, the former may be dropped from the system due to summing-up conditions, as in Mishra et al. (2012).

Data

To analyze farm financial performance in U.S. broiler production, we use 2003-2011 Phase III ARMS and 2006 and 2011 ARMS broiler cost of production survey data. The ARMS is conducted annually by the USDA's National Agricultural Statistics Service and Economic Research Service. The Phase III data include whole-farm costs and returns for a sample of U.S. farms along with information on farm size, type, structure, and farm and household characteristics. Only a limited number of farms in the Phase III data produce broilers. Every year, several farm enterprises are selected for more in-depth surveying, with questions addressing costs and returns specifically for the enterprise of interest, the use of technologies and management practices for that enterprise, and other questions of interest specifically for the enterprise. Broiler cost of production surveys were conducted in 2006 and 2011, resulting in

1,561 and 1,444 usable responses in each year, respectively. For the Phase III ARMS surveys conducted during 2003-2011, a total of 8,892 observations included broilers. Because the ARMS is a design-based survey that uses stratified sampling, weights or expansion factors are included for each observation to extend the results to the U.S. farm population. In the case of the broiler cost of production surveys, the data can be expanded to represent the largest U.S. broiler states, representing 90% of U.S. broiler production. We use the 2006 and 2011 ARMS broiler surveys to examine the impact of farm and farmer characteristics on the use of new versus old broiler housing technology and the 2003-2011 ARMS Phase III data to provide a longer-term view of the drivers of broiler farm financial performance.

Equations to Be Estimated

The three equations estimated using SUR include the following:

$$(3) \qquad \ln\left(\frac{R}{S}\right)\ln\left(\frac{R}{S}\right)=f$$

(*Appalachia, Corn Belt, Delta, Northeast, Southern Plains, Age, Spouse Off-Farm, Operator Off-Farm, Acres Operated, Chicks Sold, Proportion Broilers, New Technology, THI*)

$$(4) \qquad \ln\left(\frac{S}{A}\right)\ln\left(\frac{S}{A}\right)=f$$

(*Appalachia, Corn Belt, Delta, Northeast, Southern Plains, Age, Spouse Off-Farm, Operator Off-Farm, Acres Operated, Chicks Sold, Proportion Broilers, New Technology, THI*)

$$(5) \qquad \ln\left(\frac{A}{E}\right)\ln\left(\frac{A}{E}\right)=f$$

(*Appalachia, Corn Belt, Delta, Northeast, Southern Plains, Age, Spouse Off-Farm, Operator Off-Farm, Acres Operated, Chicks Sold, Proportion Broilers, New Technology, Heat Index, Region × THI, Region × Chicks Sold*)

These factors are hypothesized to impact U.S. broiler farm asset efficiency, profitability, and solvency, and thus the competitiveness of U.S. broiler production within the world market.

In our model, we control for the impact of region on broiler farm asset efficiency, profitability, and solvency by including six regions: *Appalachia* including Kentucky, North Carolina, Tennessee, and Virginia; *Corn Belt* including Missouri; *Delta* including Arkansas, Louisiana, and Mississippi; *Northeast* including Delaware, Maryland, and Pennsylvania; *Southeast* including Alabama, Georgia, and South Carolina; and *Southern Plains* including Oklahoma and Texas. There were relatively few California firms in the data; they were included with the *Southern Plains* farms. These 17 states, representing 90% of the value of U.S. broiler production, were included in the 2006 and 2011 ARMS broiler cost of production survey and are the only states we include in our DuPont SUR model.

Operator demographic variables included in each of the three equations include operator *Age*, predicted spouse hours per year working off the farm (*Spouse Off-Farm*), and predicted operator hours per year working off the farm (*Operator Off-Farm*). Previous studies have shown that operator age significantly influences farm financial performance. For instance, asset efficiency was lower among older U.S. farmers (Mishra et al. 2012) and older dairy farmers operated less profitable farms than younger ones (Gillespie et al. 2009).

Spouse Off-Farm and *Operator Off-Farm* are included to examine the impacts of off-farm work on broiler farm financial performance. Appendix Table 1 shows that operators and their spouses worked off farm on average 283 and 361 hours per year, respectively, over the period. Since off-farm employment can be endogenously determined with farm financial variables, the Hausman (1978) test was used to test for endogeneity in each of the three SUR equations. Endogeneity was found, so instrumental variables were substituted into the model for these two variables. Ordinary least squares estimates of the predicted values for these variables were then included in the SUR model (Appendix Table 3). Independent variables included in the *Spouse Off-Farm* model were farm net worth, government payments received by the farm, household size, accrued interest, off-farm interest income, population accessibility of the farm, value of livestock production under contract, farm operator household assets, adjusted wage rates in the area where the farm is located, and owned acres operated. Thus, these variables served as instruments for *Spouse Off-Farm.* Independent variables for *Operator Off-Farm* were the same as for *Spouse Off-Farm* except that *Age*, a household well-being dummy variable indicating that the household was above the median value of well-being, and total animal units on the farm were also included, while adjusted wage rates in the area and owned acres operated were not included. Thus, these variables, with the exception of *Age*, which is also included in the DuPont SUR equations, served as instruments for the *Operator Off-Farm* variable.

For the *Spouse Off-Farm* regression equation, all but three coefficients were significant at $P < 0.10$. For the *Operator Off-Farm* regression equation, all but two variables were significant at $P < 0.10$. With many significant drivers, it was determined that the predicted values could be used in the SUR model. Specification of these equations was heavily influenced by previous work (Gillespie and Mishra 2011; Nehring et al. 2014), who used similar specifications for instrumental variables for *Spouse Off-Farm* and *Operator Off-Farm*. It is expected that off-farm work increases financial resources available to the farm, thus potentially increasing solvency, but it may also divert management resources from the farm, which could negatively impact farm financial performance.

Variables used for farm size include *Acres Operated* and *Broilers Sold*. Both were specified as their natural logs, so their interpretation is similar to that of an elasticity. *Acres Operated* measures the total number of operated acres, serving as a measure of the size of the total farm operation, including acres in crops, pasture, and woodland. *Broilers Sold* serves as a measure of the size of the broiler enterprise. Farm size was found to increase the asset efficiency of U.S. cow-calf farms (Nehring et al. 2014) and to impact both profitability and asset efficiency of U.S. farms (Mishra et al. 2012). Appendix Table 1 shows that *Acres Operated* averaged 199 for U.S. broiler farms, ranging from 161 in the *Northeast* to 284 in the *Corn Belt*. The number of *Broilers Sold* averaged 467,400 for the U.S., ranging from 297,386 in the *Northeast* to 634,259 in the *Corn Belt.*

Proportion Broilers, defined as the value of broiler production divided by the value of total farm production, is a measure of specialization in broiler farming. Earlier studies have found that farm diversification (the opposite of specialization) impacted farm asset efficiency, profitability, and solvency (Mishra et al. 2012). Specialization in beef production was found to reduce the asset efficiency of U.S. cow-calf farms (Nehring et al. 2014). The expected impact of specialization would depend upon whether managerial gains can be expected from specialization or whether significant scope economies exist in the production of broilers along with other farm enterprises. Appendix Table 1 shows that the *Proportion Broilers* averaged 95% and ranged from 88% in the *Northeast* to 98% in the *Southeast*, showing a relatively large specialization in broilers.

The impact of technology on farm financial performance has been extensively addressed in the agricultural economics literature. Technology that improves productivity can be expected to improve long-run farm profitability and asset efficiency. It can also impact solvency if debt financing is used to purchase the technology. Technology is an important productivity driver, and increased productivity is a major factor that has influenced the increase in U.S. broiler exports (MacDonald 2008). We define new technology housing as housing that was built after 1996. New broiler housing technologies that have become more common since the mid-1990s include tunnel ventilation and evaporative cooling cells (MacDonald 2008). MacDonald states that houses constructed prior to 1995 (about 40% of housing capacity) are less likely to include these technologies and other modern technologies such as computer warning systems. Tunnel ventilation systems consist of large fans at one end of a broiler house and air inlets at the other end. Fans pull air through the house, removing heat and creating a wind chill for cooling. Evaporative cooling systems located near the air inlets can be activated for further cooling in a tunnel-ventilated house. Cooling pads, moistened by fogging nozzles, lower the air temperature as it is pulled through the pads and the house. About 75% of broiler houses had cooling cells and tunnel ventilation in 2006 (MacDonald 2008). While some houses built prior to 1996 have been retrofitted with new technology, those houses tend to be smaller and often do not include other new technologies.

As discussed earlier, we used the 2003-2011 ARMS Phase III data for the DuPont SUR. However, those surveys did not query broiler farmers as to the vintage of their houses. The 2006 and 2011 Phase III broiler cost of production surveys, however, did query growers as to housing vintage. Thus, we used the 2006 and 2011 Phase III broiler cost of production survey data to estimate a probit model to determine the probability that a broiler farmer owned broiler houses constructed after 1996. This probit model includes as independent variables dummy variables for the regions, the total number of chicks placed, total cash wages paid to labor, total reported depreciation for machinery, *Age*, whether the operator worked off-farm, the operator's education level, the debt-asset ratio, whether the household's well-being index was higher than the median value for all broiler farms, and a trend variable that was coded as 2006=0 and 2011=5. We then used the predicted values of the probit model to estimate the probability that an operation of specific characteristics used old or new technology and included these predicted values in the DuPont model. Since we expect that from 2003 to 2011, the adoption rate would have increased, a trend variable is used to adjust probabilities of adoption in the DuPont model year, with 2003 coded as -3, 2004 as -2, …, to 2011 as 5. As seen in Appendix Table 4, 10 of the 14 independent variables were significant at $P \leq 0.10$ and the percentage correctly predicted was 68.1%. Furthermore, because growers self-select into a technology, i.e. more productive growers are more likely adopt more productive technology, we correct for self-selection bias by estimating an inverse Mills ratio from the probit model to be included in the DuPont model equations.

ARMS 2011 survey indicates that there were over 70,000 broiler houses in use for meat production. Their age structure follows a hump-shaped pattern (Figure 3), with nearly two-thirds of capacity built in the 20 years between 1986 and 2006. Investment dropped sharply after 2006, as considerably less capacity was built in the 5 year period from 2006 through 2011 than in any of the four previous 5-year periods 1986-1990, 1991-1995, 1996 -2000, and 2001-2006.

Figure 4 provides a map of the temperature-humidity index (THI) for the U.S. The THI is a measure that combines relative humidity and ambient temperature and can be used to examine the impact of heat stress on animal agricultural production (West 2003). As can be seen, the highest levels of heat stress in the U.S. are experienced in some of the broiler producing regions of the southeastern U.S. Researchers have suggested that management procedures to mitigate heat stress improved broiler feed conversion and lowered mortality without affecting body weight (St. Pierre et al. 2003, Yalcin et al. 2001). Heat stress is another factor with potential productivity, and thus export, implications.

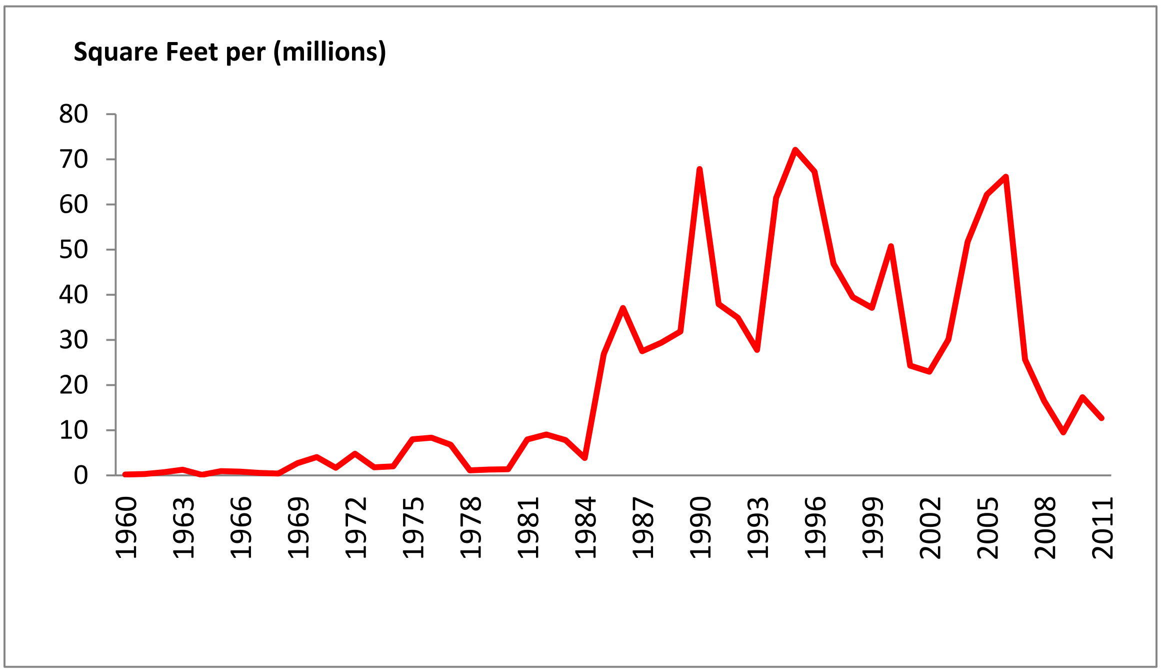

Figure 3. Boiler housing capacity by year of construction.
Source. 2011 Agricultural Resource Management Survey, Version 4.

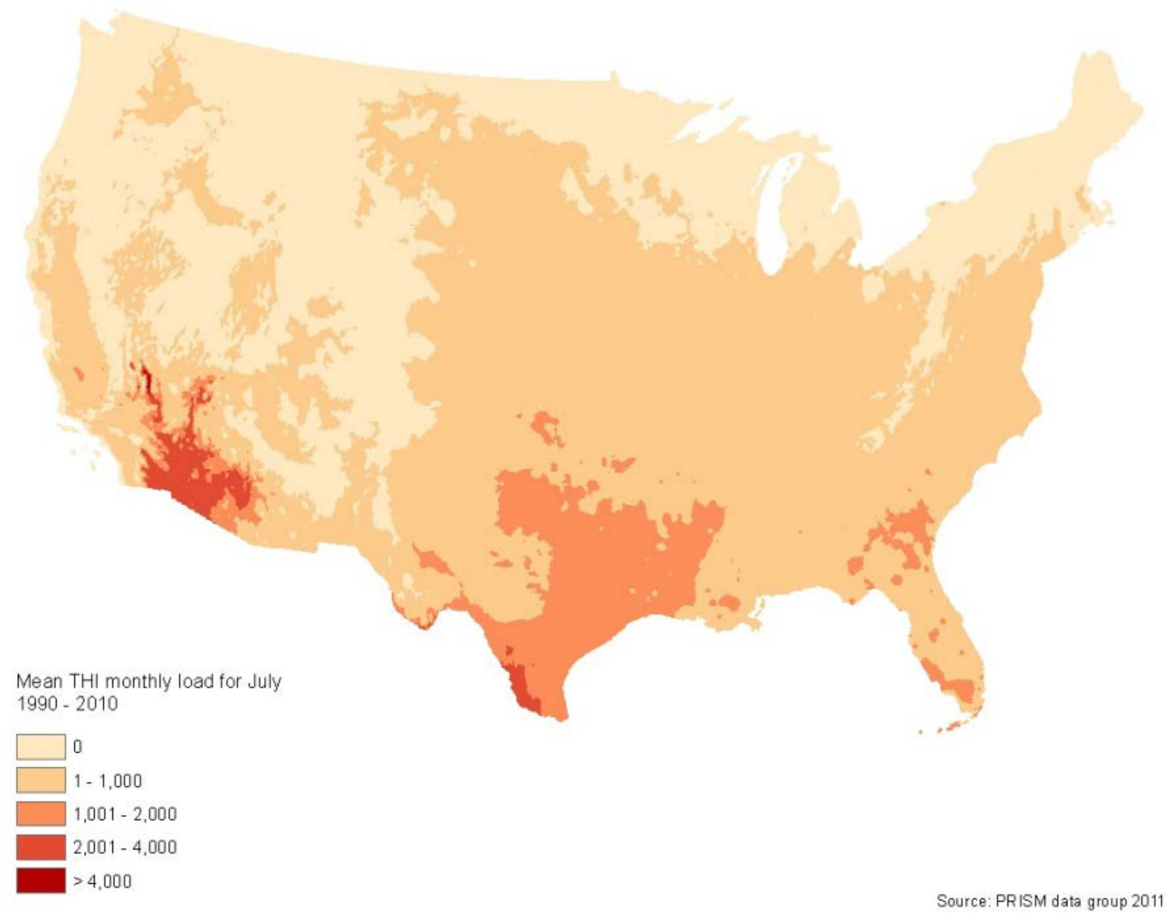

Figure 4. Heat Index Map, U.S.
Source. Prism data group and GIS/ERS calculations.

In the SUR models, independent variables were crossed with regional variables to determine whether an interaction would impact financial performance. If any one of the β estimates was substantively larger than its standard error for any of the regional crosses, all of the regional crosses for that variable were included in the model. This is similar to the method Nehring et al. (2014) used to select regional crosses for their DuPont cow-calf model. As a result, regional cross effects with *THI* and *Broilers Sold* were included in the solvency equation. The regional cross effects with *THI* could be important if managerial and technological response to a higher *THI* differed by region, impacting financial performance. Furthermore, differential farm size impacts on farm financial performance by region are investigated with the *Broilers Sold* regional crosses.

Results

Table 1 (see Appendix) shows the means for variables used in this study by region and for the whole U.S. The results indicate that inverse solvency averaged 1.26, ranging from 1.15 in the *Northeast* to 1.41 in the *Southern Plains*. This suggests that, on average for U.S. broiler farms, the value of total assets was 26% higher than the equity, or conversely the more commonly-used measure for solvency using the equity/asset ratio would be the inverse, 0.79. Profitability measured as net return over sales averaged 32.4%, ranging from 22.3% in the *Corn Belt* to 37.1% in the *Southeast.* Asset efficiency measured as sales over assets averaged 22.3%, ranging from 18.5% in the *Northeast* to 25.4% in the *Corn Belt.* Finally, return on equity averaged 9.1%, ranging from 6.2% in the *Northeast* to 10.5% in the *Appalachia* and *Delta* regions. Note that there are many reasons why these whole-farm measures of financial performance may vary by region including production conditions, average farm size, diversification and the other enterprises into which the farms are diversified, and others.

The regional main effects shown in Table 2 (see Appendix) are generally consistent with the Appendix Table 1 results. Relative to the *Southeast*, farms in the *Southern Plains*, *Delta*, and *Corn Belt* regions were less solvent and farms in *Appalachia* were more solvent. These results are consistent with the debt-asset ratios by region reported in Appendix Table 1. Relative to the *Southeast, Delta* and *Southern Plains* farms were more profitable and *Corn Belt* farms were less profitable. Regional variables will be further discussed as we discuss results of the other independent variables in the model. Overall, while important, region did not appear to be the most important driver in this analysis, as opposed to results for cow-calf operations (Nehring et al. 2014), where regional main effects showed significance and many of the regional crosses were also significant. We believe this reflects the more homogeneous general nature of broiler farms relative to cow-calf farms by region, where broiler housing has enabled producers to more effectively control the production environment of broilers. Also, broiler farms have a more homogeneous farm structure by region in terms of (1) enterprise specialization (note *Proportion Broilers* in Appendix Table 1), (2) farm size (note *Broilers Sold* and *Acres Operated*, both of which do not differ greatly by region), and (3) the impact of a limited number of integrators who have partial control over the grow-out phase.

Age was significant in two of the equations. Similar to results for cow-calf operations (Nehring et al. 2014), farms with older producers were more profitable, which can likely be attributed to greater experience. On the other hand, contrary to expectations, older producers were less solvent, suggesting that as they aged they took on more debt relative to equity. Though unexpected, it is not uncommon for older producers to take on additional debt to retrofit older housing or to expand their operations, particularly if there is a younger family member who is also involved in the operation.

On farms where the spouse worked off-farm, both profitability and asset efficiency were lower. Spouses likely provide significant unpaid labor and management to the operation that is not included in the operational costs. When the spouse works off-farm, that contribution is lost, explaining the lower levels of profitability and efficiency. The asset efficiency result differs from previous studies of U.S. farms (Mishra et al. 2012) and for cow-calf farms (Nehring et al. 2014). Operator off-farm work positively impacted farm profitability, suggesting that as with cow-calf farming (Nehring et al. 2014), operator off-farm work is complementary with broiler production. This is supported by results from a previous study which found that farmers who worked more hours off the farm were more likely to choose broilers as a farm enterprise (Gillespie and Mishra 2011). On the other hand, operators who worked more hours off the farm were more likely to experience lower asset efficiency, similar to the spousal off-farm work result. It appears that while there are differential impacts of spousal and operator off-farm work on farm profitability, off-farm employment among broiler households is consistently associated with lower farm asset efficiency.

Farm size was measured in two ways, first as *Acres Operated*, with farms operating more acres having lower asset efficiency and higher solvency. Producers with greater acreage tended to hold less debt relative to equity, but also sold less relative to their asset base. On the other hand, producers who sold more broilers experienced greater profitability, had higher asset efficiency, and were more solvent, suggesting that, as expected, significant economies of size exist in the broiler industry. Furthermore, since the coefficient on *Broilers Sold* was significant in all three equations, we can calculate the impact of broilers sold on return on equity by summing its three parameter estimates in the SUR equation: 0.5427. This suggests that larger-scale broiler operators had higher return on equity than smaller ones. From a trade perspective, these results suggest that as broiler production continues to expand internationally, the larger-scale U.S. broiler operations will be those that drive U.S. competitiveness. Though regional crosses on *Broilers Sold* were included in the asset efficiency equation because the Northeastern cross was "close" to significant, none of the crosses were significant at $P \leq 0.10$.

Proportion Broilers was significant in all three equations, suggesting that farms that are more specialized in broiler production were less profitable, had lower asset efficiency, and were less solvent. This suggests that though broiler farms tend to be highly specialized – regional averages in Appendix Table 1 show that *Proportion Broilers* ranges from 0.88 to 0.98 – more diversified farms tended to experience better financial performance. Since *Proportion Broilers* was significant in all three equations, we calculate its impact on return on equity by summing its three SUR parameter estimates: -2.7239. This suggests that more specialized broiler farms had lower return on equity than more diversified ones. From a trade perspective, these results do not suggest a need for U.S. farms to further specialize in broiler production in order to remain competitive in the global market. The result for asset efficiency is consistent with that found for cow-calf production (Nehring et al. 2014).

Farms with newer broiler houses tended to experience lower profitability, lower asset efficiency, and lower solvency. The solvency result is not surprising given the greater debt most farms with newer housing would be expected to hold. Furthermore, the profitability result is plausible considering that farms with new equipment are likely to continue to depreciate their assets on their tax returns, thus reducing net farm income. If newer housing, however, is expected to improve production efficiency, then we would initially expect asset efficiency to be higher for operations with new housing. However, it is likely that the value of the older assets is lower than that of the new assets. Therefore, having older buildings reduces the denominator of the asset efficiency measure at a greater amount than the sales numerator is reduced. Since the coefficient on *New Technology* was significant in all three equations, we calculate its impact on return on equity by summing its three SUR parameter estimates: -2.3660. This suggests that new technology operations had lower return on equity than older technology operations. We urge caution in reading too much into these results, as newer housing using the older technology would also have likely led to similar signs, with higher debt, higher-valued assets, and greater depreciation. These results may tell us more about the impact of holding new assets in general than about a specific technology. Note that the inverse Mills ratios were significant at $P \leq 0.01$ for both the profitability and efficiency equations, indicating that self-selection bias was present in the adoption of new technology and it was corrected for in the analysis.

Higher *Temperature-Humidity Indexes* were associated with greater asset efficiency and solvency, indicating that producers have adapted to heat stress through improved management. It would be of interest to examine the impact of heat stress on broilers from an international perspective to gain understanding of the interactions between technology use, heat stress, and global competitiveness. Of further interest would be to examine the impact of temperature and humidity on enterprises where the environment is less controlled than with broilers, such as cattle. Key and Sneeringer (2014) analyzed the impact of heat stress on dairy farm productivity. The lower asset efficiency of farms experiencing greater heat stress in the *Delta* region relative to the *Southeast* suggests differential impacts of heat stress by region.

Conclusions

Results of this study suggest the main drivers of higher return on equity in U.S. broiler production to be farm size, diversification, and housing vintage, where larger, more diversified farms using older housing experienced greater profitability, asset efficiency, solvency, and return on equity. Regional differences were found among farms, with the DuPont model comparing farm financial performance of the five ERS regions with the *Southeast*, the largest broiler production region. Some significant differences were found, most notably with solvency and followed by profitability, with *Corn Belt* and *Southern Plains* farms having lower profit and being less solvent than *Southeast* farms. Overall, however, the differences are not large, with the exception of the lower profitability and solvency measures in the *Corn Belt*. We believe that bigger differences in financial performance would have been found in agricultural industries that do not control the production environment to the extent of that in broilers, with climate controlled housing. The fact that the THI had the opposite-than-expected impact on financial performance is indicative of the role of management and control of the production environment in broiler production.

Another characteristic of broiler farms that has impacted farm financial performance has been off-farm income. The percentage of income from off-farm sources ranged from 11% in the *Corn Belt* to 27% in the *Southern Plains*, with many operators and spouses working significant numbers of hours off the farm. The negative impacts of *Spouse Off-Farm* on both profitability and asset efficiency likely tell us something about the opportunity cost of spousal labor off the farm. Specifically, for spousal off-farm work to lead to greater household income, the additional income from off-farm employment must exceed the reduced farm income associated with the loss of unpaid spousal labor and management on the farm. On the other hand, operator off-farm work appears to be complementary with broiler production. This result is consistent with previous work on cow-calf operations (Nehring et al. 2014). Further work on the reasons for this complementarity in production would be of interest.

A significant contribution of this study is that it provides industry benchmark information that producers and agricultural lenders can use as baseline information from which to compare their farms. From an agricultural trade perspective, industry production competitiveness is of primary importance. The U.S. has long been competitive in the world broiler market]. Continued attention to production competitiveness will be important as broiler production becomes more competitive in other countries. Results of our study suggest that the most competitive broiler farms in the U.S. are larger-scale and, interestingly, more diversified into other farm enterprises. Production region impacts competitiveness and the southeastern portion of the U.S. appears to have held the competitive edge during the 2003-2011 period. These are factors that will need to be considered as the broiler industry continues to strive to remain competitive in a global broiler market. From a trade perspective, our results suggest that as low-cost, vertically integrated broiler production continues to expand globally into developing countries (as discussed by Constance, 2008), larger-scale, diversified farms in the U.S. Southeast will have the advantage in competing in the global market.

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Appendix

Table 1. Means of Variables of Interest by Region and Whole U.S.

Table 1. Means of Variables of Interest by Region and Whole U.S.

Item	Northeast	Corn Belt	Appalachia	Southeast	Delta	Southern Plains	Whole U.S.
General Statistics by Region							
Number of Observations	504	305	1,857	2,863	2,483	880	8,892
% of U.S. Broiler Farms	10.9	2.2	21.1	31.5	26.4	7.9	100.0
% of Value of U.S. Broiler Production	7.6	2.8	21.9	33.6	24.4	9.7	100.0
Means of DuPont Independent Variables by Region							
Age	54.6	50.3	52.7	54.2	53.3	53.3	53.5
Operator Off-farm Hours	413	276	247	296	245	272	283
Spouse Off-farm Hours	321	206	321	362	407	404	361
Acres Operated	161	284	209	183	202	256	199
Broilers sold	297,386	634,259	460,386	519,078	457,951	615,065	476,400
Proportion Broilers	88	94	91	97	98	96	95
THI Index	79	285	169	335	553	823	370
Means of Other Variables of Interest by Region							
Household Net Ret on Assets	7.0	7.0	9.5	8.7	7.8	10.2	8.5
Farm Net Return on Assets	4.0	4.4	6.7	6.5	4.8	5.8	5.7
Harvested Acres	135	115	124	54	52	45	78
% Household Income Off-Farm	25.8	11.4	18.0	20.7	21.3	27.4	21.2
Land Price ($/acre)	8,995	2,023	3,494	3,738	1,982	1,638	3,413
Debt-Asset Ratio	16.4	27.8	22.8	23.1	34.5	35.0	25.7
Means of DuPont Farm Financial Performance Measures by Region							
DuPont Inverse Solvency (A/E)	1.15	1.29	1.23	1.23	1.39	1.41	1.26
DuPont Profitability (R/S)	29.2	22.3	33.9	37.1	27.4	30.0	32.4
DuPont Efficiency (S/A)	18.5	25.4	25.1	21.7	21.9	24.7	22.3
DuPont Return on Equity (S/E)	6.2	7.3	10.5	9.9	10.5	10.4	9.1

Table 2. Results of the DuPont Seemingly Unrelated Regression Model

Table 2. Results of the DuPont seemingly Unrelated Regression Model

Independent Variables	**Profitability (R/S)**			**Efficiency (S/A)**			**Inverse Solvency (A/E)**		
	β		**Standard Error**	**β**		**Standard Error**	**β**		**Standard Error**
Constant	-3.0437	*	1.6380	-1.2418	**	0.5298	-0.0406		0.2475
Appalachia	-0.0281		0.1052	0.1348		0.6671	-0.0682	***	0.0206
Corn Belt	-0.3988	**	0.1982	0.4074		0.8217	0.4599	***	0.0455
Delta	0.1690	*	0.0969	0.4921		0.5322	0.0973	***	0.0191
Northeast	-0.0803		0.1552	-0.9917		0.7640	0.0120		0.0360
Southern Plains	-0.3744	**	0.1557	0.3692		0.9253	0.1817	***	0.0474
Age	0.0559	***	0.0131	0.0032		0.0024	0.0118	***	0.0017
Predicted Spouse Off-Farm	-0.0012	***	0.0002	-0.0004	***	0.0002	0.0001		0.0001
Predicted Operator Off-Farm	0.0064	***	0.0012	-0.0004	***	8.5E-5	0.0001		0.0001
Acres Operated	-0.0310		0.0357	-0.1548	***	0.0142	-0.0431	***	0.0080
Broilers Sold	0.3868	***	0.0829	0.2654	***	0.0372	-0.1095	***	0.0275
Proportion Broilers	-0.9925	**	0.4031	-1.9765	***	0.1612	0.2451	***	0.0853
New Technology	-3.6289	***	0.3754	-1.1472	***	0.1476	2.4101	***	0.1499
THI	0.0002		0.0002	0.0003	**	0.0001	-0.0001	*	4.3E-5
Inverse Mills Ratio	-1.1655	***	0.1755	-1.00071	***	0.0757	0.0409		0.0341
Appalachia × THI				0.0001		0.0003			
Corn Belt × THI				-0.0001		0.0003			
Delta × THI				-0.0004	***	0.0002			
Northeast × THI				0.0007		0.0015			
Southern Plains × THI				-0.0001		0.0002			
Appalachia × Chicks Sold				0.0004		0.0503			
Corn Belt × Chicks Sold				0.0111		0.0628			
Delta × Chicks Sold				-0.0105		0.0403			
Northeast × Chicks Sold				0.0734		0.0623			
Southern Plains × Chicks Sold				0.0211		0.0698			
Adjusted R-Square	0.1751			0.2547			0.5104		

Table 3. Results of Probit Model, 1=Housing Constructed Since 1996; 0=Housing Constructed Before 1996

Independent Variables	β		Standard Error
Constant	0.3494		0.2322
Appalachia	-0.0276		0.0553
Corn Belt	-0.3896	***	0.1513
Delta	-0.1060		0.0736
Northeast	-0.0309		0.1319
Southern Plains	-0.1233		0.1585
Chicks Placed	0.0024	***	0.0006
Cash Wages	-0.0018	***	0.0005
Depreciation on Machinery	0.0006	***	0.0002
Age	-0.0219	***	0.0033
Operator Holds Off-Farm Job	-0.0014	***	0.0007
Operator Education	-0.0288		0.0239
Debt-Asset Ratio	0.9042	***	0.1916
Household Well-Being Above Median Level	0.0714	**	0.0342
Trend	0.0726	***	0.0109

Table 4. Results from the Operator and Spouse Off-Farm Employment Hours Regressions

Independent Variables	Spouse Off-Farm			Operator Off-Farm		
	β		Standard Error	β		Standard Error
Constant	-136.03		166.54	1116.72	***	159.08
Farm Net Worth	-2.21		2.60	2.52		2.30
Government Payments	0.46		0.96	-2.58	***	0.87
Household Size	64.52	***	5.23	14.95	***	5.15
Accrued Interest	2.07	**	0.92	1.56	*	0.87
Off-Farm Interest Income	2.90	***	0.85	2.75	***	0.77
Population Accessibility	-60.60	***	11.60	29.67	***	10.46
Value Livestock Production under Contract	-18.73	***	6.18	-42.11	***	5.84
Household Assets	58.61	***	12.45	-10.37		11.47
Adjusted Wage Rates in Area	15.23	***	0.71			
Acres Operated	-2.99		4.19			
Age				-9.77	***	0.69
Household Well-Being Above Median				50.51	***	7.18
Total Animal Units				3.90	***	1.13

International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Pricing-to-Market and Exchange Rate Pass-Through in the U.S. Broiler Meat Export Markets[1]

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Abstract

The conventional estimation method of the pricing-to-market (the PTM) model in the international trade literature is a within model of panel regression of export prices on exchange rates with time and country dummies. Previous studies have found a significant coefficient parameter in exchange rate variable, which is only indicative of short-run pricing-to-market for multiple export destinations rather than long-run pricing behavior. This paper examines a long-run pricing-to-market for U.S. broiler meat export markets, using “between” panel specification. Findings indicate that the U.S. pricing-to-market behavior of exporters is both transient and persistently long. These results clearly imply that the implementation of a long-run pricing-to-market strategy in the U.S. broiler meat exports mitigates the rising imbalance between the domestic production and consumption via incomplete exchange rate pass-through.

Keywords: pricing-to-market, broiler meat export, within regression, between regression, panel data

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[1] The views expressed here are those of the authors, and may not be attributed to Southern University, the Economic Research Service or the U.S. Department of Agriculture.

Introduction

The U.S. is the largest poultry producer in the world (Davis et al. 2013). However, one of the concerns that some poultry firms have is the potential imbalance between rising U.S. domestic production and stagnant domestic consumption and its detrimental impact on domestic producer prices. This would also have a major ripple effect on prices and overall poultry revenues as domestic consumption accounts for approximately 80% of their production.

Price analysis has long been one of dominant subjects in agricultural commodity markets. Continuous research on the competitiveness of the export price appears as one of the important focus points of the literature in international economics. In a free market and pure floating exchange rate system, broiler export prices will be the same for all destinations. There will be no country specific effects, and changes in the bilateral exchange rates will not affect bilateral export prices.

On the other hand, in an oligopoly market, an exporter with market power may not pass through exchange rate changes into export prices because of concerns about market shares. Thus, exporters with market power might implement a “long-run pricing-to-market strategy” to keep their market shares on the international market intact or increasing by keeping their foreign price constant despite an appreciation or depreciation of the domestic currency (i.e., incomplete exchange-rate-pass-through).

In theory, “there are two critical assumptions underlying the ability to exercise noncompetitive pricing across markets: first, the markets must be separated in space, time, form or some other dimension. This separation must be maintained so that there is no possibility for arbitrage. Secondly, the response of demand to price changes must differ between markets so that the link between prices and marginal revenues varies in the different markets” (Griffith and Mullen 2001, 324). In the broiler export trade, these assumptions may well be met.

Several models[2] have been developed to examine price behavior of firms with monopoly power across export destinations (Krugman 1987; Dornbusch 1987; Knetter 1989). These models have been used to determine if exporters exercise pricing-to-market in several empirical studies (Carew 2000; Griffith and Mullen 2001; Miljkovic et al. 2003). Earlier research used a two-way fixed effects (or within) regression model in which an exchange rate variable is used to measure

[2] Before a new trade theory was introduced into the industrial organizational literature, the conventional approach to measure market power was the Lener’s index. Lener’s index is a ratio of mark-up of price to marginal cost. However, the estimation of the actual marginal cost to calculate the Lerner’s degree of monopoly power is quite challenging and accounting data are not appropriate to measure marginal cost (Fisher and McGowan 1983).

Krugman (1987), the founding father of the new trade theory, popularized a simple specification of the bivariate relationship between export prices and exchange rates to examine the pricing-to-market behavior of exporters, based on the theory that an exporter with market power can keep its destination-specific import prices unchanged or raise it when an importer’s currency appreciates relative to the exporter’s currency or vice versa. The advantage of the Krugman’s PTM model is its simplicity of specification and interpretation. This study follows his convention by employing two variables: export price and exchange rates.

the exchange rate pass-through for an individual importing country with two dummy variables being used to capture common time effect and country effect. General interpretation of significant exchange rate coefficients in the traditional two-way within model is that exchange-rate changes are associated with markup variation that is specific to each destination market. At the same time, the country control variable is assumed to capture different quality and markup across markets that do not vary over time, while the time control variable is used to capture the change in markups that is common-across-markets.

Econometrically, the single two-way within specification regresses the country-specific deviations from the mean (an average across countries) of the dependent variable on the country-specific deviations from the means of the independent variables. Therefore, the exchange rate coefficient obtained from a single country-level within regression should be interpreted as an estimate of a short-term or transient noncompetitive pricing, because the specification is focused on movements away from the estimates of complete exchange pass-through from year to year. Thus, the use of the single within model is not warranted to examine "long-run pricing-to-market strategy" of noncompetitive exporters, which requires a time-average component in estimation.

Baltagi (2005, 21) and more recently, Chernenko and Faulkender (2011) suggested an alternative approach to the conventional two-way within model for long-run analysis. They argued that a "between" specification in panel data provides an estimate of long run pricing behavior of pricing-to-market. Their argument is based on the fact that a between specification in a panel data analysis regresses the mean (an average across time) of the dependent variable on the means of the independent variables over the entire sample period. Hence, a coefficient estimates in the exchange variable from the between regression yields an appropriate estimate for a time-averaged long-run pricing across export destination markets.

The primary objective of this study is to examine a long-run as well as a short-run pricing-to-market for U.S. broiler meat exporters, using within regression and between regression. Within regression results show how broiler meat exporters implement short-term pricing-to-market behavior. On the contrary, the between regression results display how broiler meat exporters execute their long-run pricing strategy through exchange rate pass-through. One of the contributions of this paper is the introduction of between regression, which is a new attempt to examine long-run pricing-to-market in U.S. poultry meat exports.

U.S. Broiler Meat Exports

Over the period of 1990 to 2011, U.S. broiler exports have experienced a tremendous surge in volume from 1.1 billion pounds in 1990 to 7.0 billion pounds in 2011 (U.S. Commerce 1990-2011). This growth was the result of larger shipments to traditional markets such as Canada and Mexico; the opening of trade to countries such as Russia, China, and Cuba; and the development of new markets for U.S. broiler products in Asia, the Middle East, and Africa.

The growth in volume of U.S. broiler exports has not been a steady progression. With access to the Russian market, exports grew rapidly in late 1990's and reached 5.5 billion pounds in 2001

(U.S. Commerce 1990-2011). However, with Russia placing restrictions on imports, overall exports later declined and it was six years before total exports exceeded the 2001 level.

Changes in export demand have different impacts on prices for various broiler parts. Sales of breast meat, either bone-in or boneless product, are almost exclusively a domestic product and are not greatly impacted by export demand. A much greater percentage of parts such as leg quarters and wings are exported and therefore their prices are more directly affected by varying export demand.

Annual average prices for broiler leg quarters have ranged from $0.19 per pound in 1999 to $0.47 per pound in 2011 (USDA-AMS 1990-2011). A good example of the impact of changes in exports on broiler parts prices is in the 2001-2002 period. At this time, leg quarter shipments were the largest portion of overall broiler exports, with Russia being the primary market. With exports expanding especially to the Russian market, prices for leg quarters averaged $0.28 per pound in 2001 and prices averaged over $0.30 per pound in the second half of the year (USDA-AMS 1990-2011). However, when Russia placed restrictions on broiler imports from the United States, prices for broiler exports fell sharply. In 2002, the average price for leg quarters declined to only $0.20 per pound (USDA-AMS 1990-2011). Prices for leg quarters only gradually increased in the following years as increased domestic production and declining shipments combined to limit price increases.

Prices for wings varied widely in the period 2000 to 2011 after being relatively stable in the previous decade. In 2003, wing prices averaged $0.77 per pound, but with increased exports to China and growing domestic demand, the average price rose 44 percent to $1.11 per pound in 2004. Wing prices then varied strongly in the next several years with the average price falling in both 2005 and 2006 before again increasing sharply to $1.23 per pound in 2007 (up 41 percent from the previous year.

With the largest single broiler export product being frozen leg quarters, overall unit prices for exports have been heavily influenced by changes in this price. In the first several years of the 1990’s, overall unit values for all broiler exports were relatively stable, averaging in the low $0.40’s per pound (USDA-ERS). With large increases in U.S. production placing downward pressure on prices, average unit values fell to around $0.30 per pound in the early 2000’s. Partially, this was a response to the decrease in leg quarter exports and the steep fall in their price in 2002 pushed average unit values to only $0.29 per pound (USDA-ERS). Since 2002, average unit prices for all broiler exports have been gradually rising with the average unit value reaching $0.52 per pound in 2011 (USDA-ERS).

In a recent publication, Davis et al. (2013) assessed the growth of U.S. poultry meat exports and attributes the surge in U.S. broiler exports to world economic growth, the continued concentration of population growth in urban centers, and the value of the U.S. dollar relative to currencies in importing countries. Out of these factors, this study further examines a bivariate relationship between U.S. exchange rates and poultry trade prices to explain U.S. dominance in the broiler exports.

Literature Reviews

Understanding the factors affecting price and exchange rate behavior between international and domestic trading partners is an important concept that impacts the viability of countries' national income and companies' profitability. Although traditional trade theory of law of one price predicts a complete pass-through exchange rate into trade prices, a battery of empirical studies on agricultural commodity exports reported evidence against the theoretical predictions. Poultry companies and other meat industries are paying close attention when importing countries' local product price does not correspond to fluctuations in exchange rates.

Studies that analyze price and exchange rate pass-through are thoroughly discussed in the pricing-to-market (PTM) literature involving various agricultural commodities from different countries. Pick and Park (1991) applied the PTM model to examine the competitive structure of U.S. agricultural exports: wheat, corn, cotton soybean, and soybean meal and oil. Their empirical results indicated that the U.S. firms have not exercised price discrimination across destination markets for cotton, corn, and soybeans. In order to examine the pricing behavior of Canadian and U.S. argi-food exporters, Carew (2000) selected wheat, pulse, and tobacco that differ in institutional market arrangements and demand characteristics. He employed the PTM model and confirmed the evidence of pricing-to-market for both the U.S. and Canadian exporters.

The PTM model has also been applied to meat products in numerous studies including (Swift 2000; Miljkovic et al. 2003; Zhao et al. 2011). Swift (2000) examined the pass-through of exchange rate changes to prices of Australian dairy and livestock exports. Their findings reveal that the pass-through of Australian dairy export prices is complete, but there is an inconsistent relationship between exchange rates and prices for other livestock products.

Miljkovic et al. (2003) examined the impact of exchange rate pass-through and price discrimination from a U.S. meat export prices perspective. Their findings suggested that there were several incomplete exchange-rate pass-through that took place in meat trade between the U.S. and other countries. Findings for this study also suggested that trade liberalization, particularly GATT, had a positive impact on U.S. beef and poultry export prices.

Zhao et al. (2011) analyzed price pass-through for beef cattle prices. They noted that in an efficient market, feeder cattle prices should be products of present feed prices and future fed cattle prices. Findings from their study suggest that fed cattle price accounts for about 93% of complete pass-through. They also found that increases in corn price had a negative impact on feeder cattle price with pass-through of about 87% of the corn price change.

Exclusive estimation method of the PTM in the earlier studies is a within specification of panel regression that is only to provide a short-run pricing behavior in export destination markets. For complete analysis, this study introduces a between specification of panel to document a long-run pricing-to-market strategy of U.S. broiler exporters. In addition, this paper compares and contrasts a within model and a between model in terms of estimating a short-run and a long-run non-competitive pricing in the broiler export markets.

Model Development

A body of literature on pricing to market model of Krugman (1987), Dornbusch (1987) and Knetter (1989) (hereafter KDK model) and their econometric methods were reviewed initially. These economic models are important and essential in that they yield an econometric model to estimate the PTM model for short-run analysis.

Consider an exporter who has market power and can use exchange rate changes in order to "price to market." Then, assume that this exporter maximizes profit by selling poultry to *N* foreign destinations, each with a unique demand function. Also, presume that this exporter can behave as a monopolist, segmenting markets and adjusting export prices to bilateral exchange rate changes. Note that demand in each market (Q_{it}) is represented as,

$$(1)\ Q_{it} = f(E_{it}P_{it})\, v_{it},\ i = 1, \ldots, N \text{ and } t = 1, \ldots, T,$$

where P_{it} is price in terms of the exporter's currency, E_{it} reflects the market specific exchange rate in period *t*, where the observations corresponding to the prices in country *i* are the market-specific exchange rate, and zero when there is no trade. v_{it} is a random variable that may shift demand in market *i* in period t.

The exporter's cost is given by

$$(2)\ C_t = C\left(\sum Q_{it}\right) \delta_t,\ t = 1, \ldots, T,$$

where C_t measures costs in the exporter's domestic currency units, which are summed over all destination markets, and δ_t is a random variable that may shift the cost function (e.g., changes in input prices) in period *t*. Substituting equation (1) for Q_{it} in equation (2), the maximization problem becomes

$$(3)\ \text{Max } \Pi = \sum\left[P_{it}\, f(E_{it}P_{it})v_{it}\right] - C\{\sum[f(E_{it}P_{it})v_{it}]\}\delta_t .$$

Differentiating equation (3) with respect to P_{it} and expressing in terms of elasticities, the first order conditions are

$$(4)\ P_{it} = c_t\left(\frac{\varepsilon_t^i}{\varepsilon_t^i - 1}\right),\ i = 1,\ldots, N \text{ and } t = 1,\ldots,T ,$$

where c_t is the marginal cost ($\frac{\Delta C}{\Delta Q}$) of production in period *t* and ε_t^i is the demand elasticity for imports in importing country *i* in period t. Equation (4) states that the price discriminating monopolist will equate marginal cost to marginal revenue in each market.

If the elasticity of demand in the importing country is not constant, then changes in the bilateral exchange rate between the exporter and the importer will cause the optimal markup to change. When demand schedules are less convex than a constant elasticity schedule, elasticity of demand increases with increases in price or vice versa (Knetter 1989)[3]. Markups of price over cost fall when the exporter's currency appreciates.

Pick and Park (1991) states that mark-up: $\frac{P_{it} - MC}{P_{it}} = -\frac{1}{\varepsilon_t^i}$ For the competitive firm, MR= P = MC, the right hand side equation equals zero, which means that the elasticity of demand in the right hand side equation should be infinitely large (e.g., price taker).

To test whether exporters can vary prices across destinations or with changes in exchanges rates, they define an empirical model:

(5) $\ln P_{i,t} = \alpha + \sum \phi_t x_t + \sum \lambda_i x_i + \sum \beta_i \ln E_{i,t} + u_{i,t}$, $i = 1, \ldots, N$ and $t = 1, \ldots, T$, where

$P_{i,t}$ is the export unit value to market destination country i in period t; x_t is a dummy variable to cap the exporting country; ϕ_t measures the time effect corresponding to the t periods; λ_i measures the country effect corresponding to the individual i destination markets; β_i measures the exchange rate pass-through for the individual i countries; and $u_{i,t}$ is error term.

The two-way within regression model in equation (5) examines export pricing behavior across destination markets. The identifying assumptions are that λ_i measure the country effect corresponding to the individual i destination markets and that β_i measure the exchange rate pass-through for the individual i countries, while $u_{i,t}$ is error term. However, if exporting countries use changes in exchange rates only for a long-run pricing-to- market strategy, not for short-run pricing-to-market, but then it is no longer clear how to interpret the empirical findings of Yumkella et al. (1994) and Griffith and Mullen (2001).

The paper proposes an alternative and direct panel analysis for estimating a long-run pricing-to-market strategy: a between estimator. Econometrically, a within estimator estimates short-run effects, because it is based on the time series component of the data. The within estimator regresses the country-specific deviations from the mean of the dependent variable on the country-specific deviations from the means of the independent variables as such:

(6) $\ln(p_{i,t} - \frac{1}{T}\sum P_i) = \alpha + \beta \ln(E_{i,t} - \frac{1}{T}\sum E_i) + u_i$, $i = 1, \ldots, N$ and $t = 1, \ldots, T$,

where β = a measure of noncompetitive pricing, because the estimator focuses on movements away from the estimates of complete exchange pass-through from year to year price. E_{it} reflects the market specific exchange rate in period t, where the observations corresponding to the prices in country i are the market-specific exchange rate, and zero otherwise.

In practice, one can take several steps to make equation (6) easily estimable. For example, take the data on individual country i as in

(7) $P_{i,t} = \alpha + \beta E_{i,t} + v_i$, $i = 1, \ldots, N$ and $t = 1, \ldots, T$,

[3] As a strong assumption suggested by an anonymous reviewer, all the importers might have the same demand schedules, but are different location on it, because of other non-homothetic demand shifters.

Next, average the data across time by summing both sides of the equation for each country and dividing by the number of periods, T. Then, subtract the time-averaged equation from equation (7) and take logarithm to the both sides. These elaborate steps yield an estimable single equation (6) for the entire panel data. It is a usual practice in estimating panel data models that one is more interested in the coefficients of the explanatory variables and not the individual intercept parameters (Hill et al. 2008, 395). In this study, an econometric software package, E-views was used to estimate equation (6).

On the other hand, the between estimator (cross sectional only) measures the long-run effects; it tells us the price discrimination. It regresses the mean of the dependent variable on the means of the independent variables as follows:

$$(8)\quad \ln\left(\frac{1}{T}\sum p_i\right) = \alpha + \beta \ln\left(\frac{1}{T}\sum E_i\right) + u_i, \quad Ii = 1,\ldots, \mathrm{N},$$

where β = a measure of pricing-to-market across export destination markets due to estimation of cross-sectional variables over the long- run, E_i reflects the market specific exchange rate of exporting country *i* on time average.

Results from country-level within regression can be interpreted as explaining transient pricing-to-market practices, since the specification focus on movements away from the estimate of the firm's constant unit export price. The coefficients generated by this specification explain which country variables are associated with deviations from the firm's average position. On the other hand, a significant coefficient in the exchange variable in the between estimator is more likely to be associated with a long-run pricing-to-market strategy. A coefficient of -1 on the exchange variable indicates a complete exchange rate pass through; 0 shows no pass-through. A coefficient between these two numbers suggests incomplete pass-through, indicating evidence of pricing-to-market. This decomposition enables us to show an individual evidence for a short-run pricing-to-market practice and a long-run pricing-to-market strategy separately. These dichotomized empirical results have not been documented in the previous monotonic pricing-to-market (PTM) research.

Our hypothesis is motivated by the literature and theory which suggests that the long-run impact on economic variables matters. All the previous pricing-to-market research in panel analysis used a within effects model, which only produces an estimate for a short-run pricing-to-market practice. Moreover, a significant short-run pricing-to-market estimate is not warranted to fully describe a long-run pricing strategy in which expanding market shares might be one of solutions to a rising imbalance between U.S. domestic broiler production and domestic consumption.

Data

The U.S broiler industry ships its meats to 109 countries (FAS, USDA). Among these export destinations, 36 countries are selected for this study. Although ideal panel data should include all the export destination countries, sufficient long panel and data continuity renders about one third of the universe useable for analysis. These 36 countries accounted for over 75% of total U.S. export broiler trade. Annual export value ($) and export volume (1,000 kg) for the selected countries are obtained from the USDA/FAS website at http://apps.fas.usda.gov/gats/default.aspx.

The data span from 1990 to 2011. Exchange rates in direct quotations (U.S. dollars per a foreign currency) are obtained from International Financial Statistics. The study adopts a panel analysis used by Baltagi (2005) and Chernenko and Faulkender (2011). It employs a within and a between specifications in panel data to appropriately capture pricing behavior of U.S. broiler meat exports to the selected destination markets.

Empirical Results

The paper decomposes pricing-to-market activities into their cross-sectional (between regression) and time-series components (within regression). The significant negative coefficient in the within specification in Table 1 indicates that incomplete exchange-rate pass-through occurs for U.S broiler meat exports. Export prices are adjusted upward by 4.6% for a 10% appreciation of the U.S. dollar relative to the foreign currencies. A significant "between" exchange rate coefficient parameter (p-value = 0.025 not reported in Table 1) indicates that the broiler meat exports persistently exercise non-competitive pricing. In the long run, exporters would adjust their prices upward by only 0.54% for a 10% appreciation of the U.S. dollar relative to the foreign currencies. The mix of the short-run pricing practice and the long-run pricing-to-market strategy across U.S. export destinations could explain the ample growth of U.S. broiler meat exports during the sample period. For managers and policymakers, this study suggests that U.S. broiler meat exporters have been making a considerable effort to expand their international markets, and its long-run pricing-to-market strategy appears to work through incomplete exchange rate pass-through.

Table 1. Within and Between Estimations for Impacts of Exchange Rates on U.S. Broiler Meat Export Prices: 1990-2011

	α		β		r^2
OLS	-0.0904		-0.0531		0.07
	(-4.97)	**	(-7.71)	**	
Within	-0.6604		-0.4562		0.49
	(-7.37)	**	(-7.26)	**	
Between	-0.0446		-0.0541		0.11
	(-0.74)		(-2.34)	**	

Note. Coefficients are elasticities and numbers in parentheses are t-statistics. ** indicates a statistical significance level of 5%.

In fact, expanding market-shares of U.S. broiler meat exports by implementing incomplete exchange rates pass-through has been a strategically viable plan, given the rising imbalance between U.S. domestic broiler production and consumption. Between 1997 and 2012, U.S. broiler meat production rose by 35.8%, from 12.2 mmt in 1997 to a high of 16.6 mmt in 2012; on the contrary, domestic per head broiler consumption showed a tepid growth of 12.5% from 32.4 kg per head to 36.5 kg per head during the same period.

Discussion

The conventional econometric model to examine exporter's price behavior across its destinations is a two-way within model of panel regression of exchange rates on export prices with time and country dummies. Findings of a significant coefficient parameter in the exchange rate variable on the conventional within model ought to be interpreted as evidence of short-run pricing-to-market only. On the other hand, between specification produces a parameter estimate for long-run pricing-to-market behavior.

This study found statistically significant coefficients in the within and the between model, indicating that the pricing-to-market of U.S. broiler exporters across their export destinations are both transient and persistently long. These results add further evidence of pricing-to-market behavior in the exchange rate pass-through literature. Furthermore, the negative significant coefficients in both the within and the between models agree with what Davis et al. (2014) found and suggest that U.S. broiler meat exporters offer broiler meat at a partially-exchange-rate adjusted price to defend its market share in the selected destination markets, followed by a strong appreciation of U.S. dollar relative to the currencies of the importing countries.

The potential imbalance between rising U.S. domestic production and stagnant domestic consumption could be a major concern, because a stagnant domestic consumption tends to put a downward pressure on price. In 2013, the U.S. accounted for about 23% of the world's broiler meat exports, while Brazil accounted for about 24% (GTIS 2015). U.S broiler meat exporters operating in oligopoly markets perceive export volumes rather than export prices to be their strategic variable to accommodate an outgrowth of domestic production. On average, the U.S. broiler meat exporters exercise a price-to-market strategy in their export markets, monetizing differential incomes and demand elasticities across export destination markets. Information on pricing-to-market behavior in the long-run as well as in the short-run could prove to be beneficial to the poultry industry because it allows for better timing of decisions given volatile exchange rate changes.

Lastly, this study shows that the outgrowth problem of U.S. broiler meat production has generated ample opportunities to U.S. broiler meat exporters. In other words, by implementing a long-run pricing-to-market strategy, U.S. exporters, who operate in the oligopoly market, have managed to mitigate a rising imbalance between the domestic production and consumption via incomplete exchange rate pass-through. In general, it is expected that if broiler export demand rises, domestic consumers will pay higher prices for broiler meat, which implies that producers will experience gains, while consumers will lose in the analysis of welfare.

Examination of a long run pricing-to-market in poultry export markets also has several merits in implications for policy. First and foremost, policy makers must be careful when evaluating policy impacts; policies may be ineffective in the short run but in the long run proved to be effective. Therefore, policy evaluation procedures should not be implemented too soon. Secondly, policy makers who are aware, a priori, that impacts vary across time, can better time their decision making if differences between long and short run impacts are known. Finally, policy makers can use these differences to dampen short run expectations on part of business and consumers who will be influenced by exchange rate changes.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Georgia's Poultry Industry and Its Impact on the Local Economy and Global Trade

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Abstract

The following paper describes and contextualizes the state of Georgia's poultry industry and its impact on the local economy and global trade. As consumer and industry demand for poultry continue to rise, Georgia emerges as the top producer of poultry in the USA. Historically and economically important to the Peach State and the world, this paper touches trends in Georgia's broiler industry, Georgia's role in the global broiler market, factors affecting Georgia broiler exports, and implications for Georgia's agricultural sector and state economy. Today, being a poultry farmer in Georgia means more than serving the family, county, or state—it means serving the nation and the world.

Keywords: poultry, broiler chickens, agriculture, export

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Introduction

The poultry industry was changed immensely by Jesse Jewell, a civil engineer and businessman from North Georgia. Mr. Jewell started selling baby chicks and feed to Georgia farmers on credit, buying back adult chickens at a price that covered his costs and guaranteed the farmers profits. After gathering enough farmers to reliably produce broilers—chickens specifically raised for meat—Mr. Jewell invested in his own processing plant and hatchery. This single action gave vertical integration a permanent place in the structure of the poultry industry and is credited with revolutionizing the Georgia poultry industry (New Georgia Encyclopedia 2014). Mr. Jewell's small-scale, backyard operations are now massive production centers that employ thousands of people and produce poultry for very specialized consumers. Poultry is currently the largest segment of agriculture and agribusiness in the state of Georgia and comprises almost half of the state's agricultural production (Figure 1). As consumer demand and industry demand for poultry continue to rise, Georgia emerges as the top producer of poultry in the country. Today, being a poultry farmer in Georgia means more than serving the family, county, or state—it means serving the nation and the world.

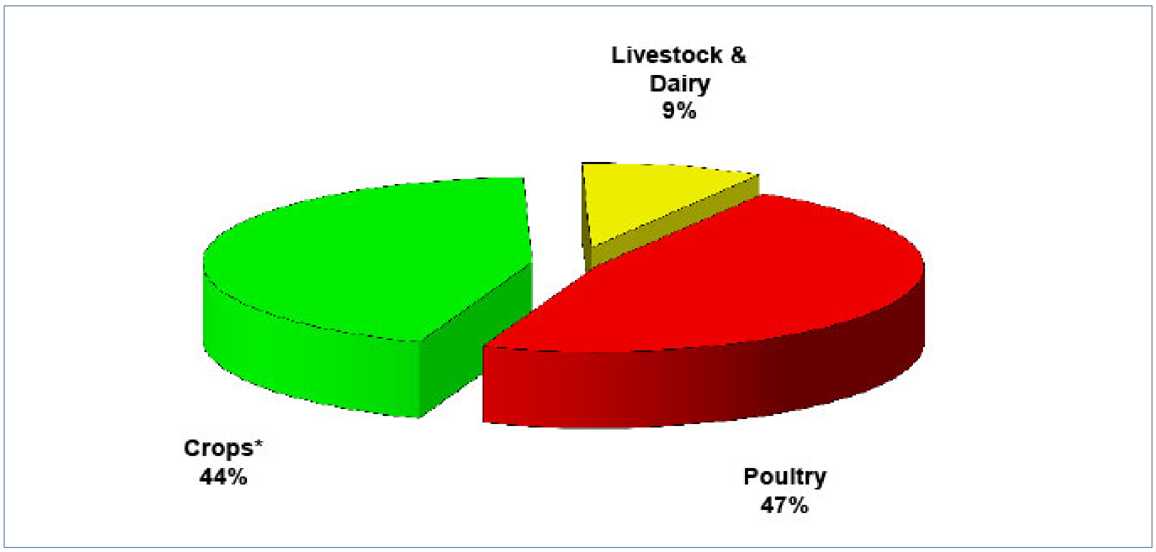

Figure 1. Poultry is the Largest Segment of Agriculture in the state of Georgia

Note. Percent by total commodity. Crops include row crops, vegetables, nuts, nursery greenhouse, hay and turf grass.
Source. Prepared by Georgia Poultry Federation. University of Georgia, 2011 Farm Gate Value Report.
Updated July 2014.

Trends in Georgia Broiler Industry

As previously mentioned, Georgia is the top producer of poultry and broilers in the U.S. Since the 1970s, broiler production has increased five-fold from approximately 1.5 billion pounds per year to 7.5 billion pounds per year (Figure 2).

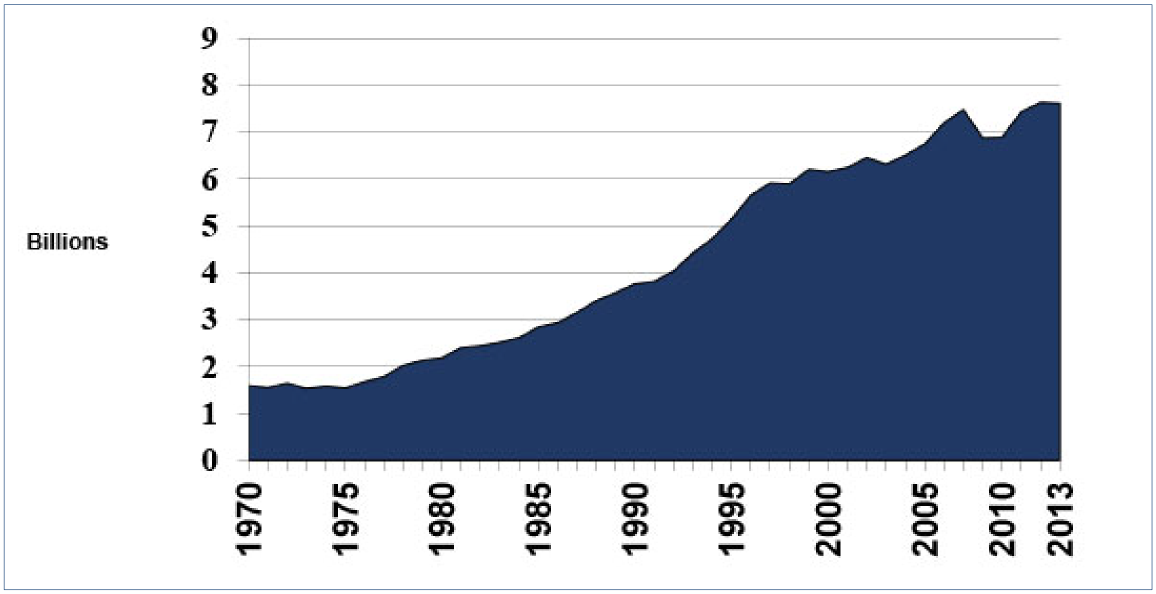

Figure 2. Broiler Growth in Georgia. Pounds Produced: 1970 - 2013
Source. Georgia Poultry Production. USDA NASS. Updated July 2014.

Aside from Georgia, Arkansas and Alabama are also top states for broiler production and they have been for several decades. In 1992, Arkansas was the top producer of broilers and Georgia was third for production. Today, Georgia is at the top while Arkansas is third (Figure 3). While the second and third place positions for broiler production have changed several times, Georgia has unequivocally held the top spot for more than 15 years. Furthermore, the gap between production in Georgia and the next highest producer has also been steadily increasing since 1996, suggesting that Georgia is gaining stronger footing of its position as the top producer of broiler chickens in the U.S.

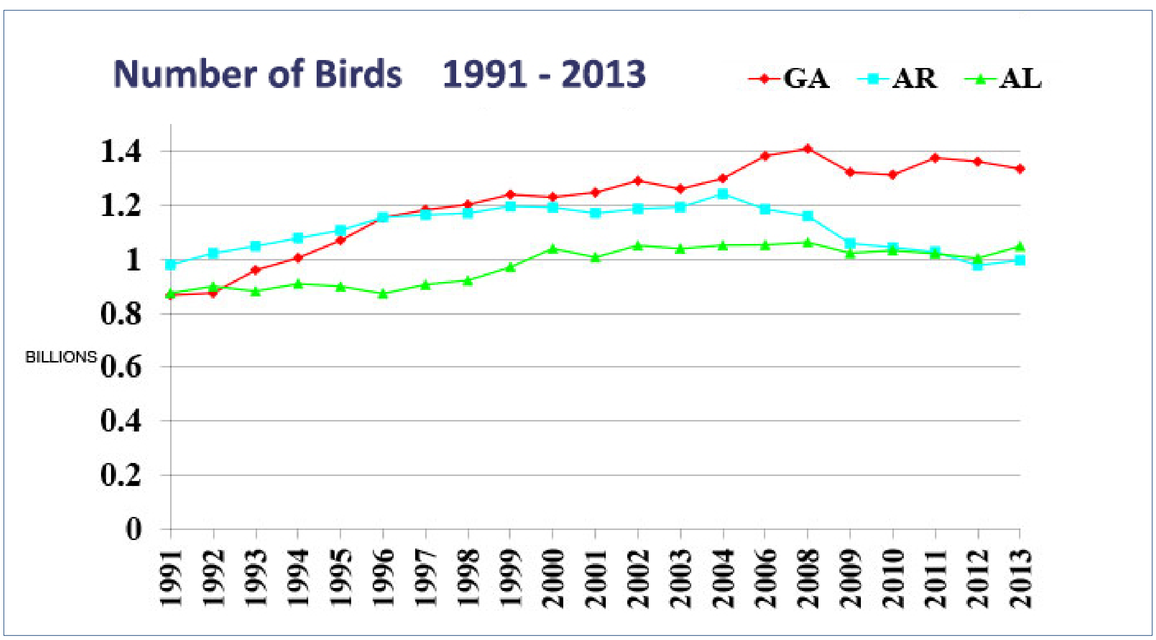

Figure 3. Top Three States in Broiler Chicken Production, 1991 – 2013
Source. Georgia Poultry Production. USDA-NASS. Updated July 2014.

Another trend in the broiler industry has been steady improvements in various aspects of broiler production. From 1925 to 2012, the weight of an average broiler more than doubled while the number of weeks needed grow a chicken fell by 56%, the pounds of feed required for each pound of chicken fell by 61%, and the percent mortality fell by 78% (Figure 4). This suggests that innovative technology and techniques have led to the production of bigger chickens without compromising the amount of feed and time needed to grow them. In the next few decades, the broiler industry will probably be peaking in its innovations in growing time and feed efficiency.

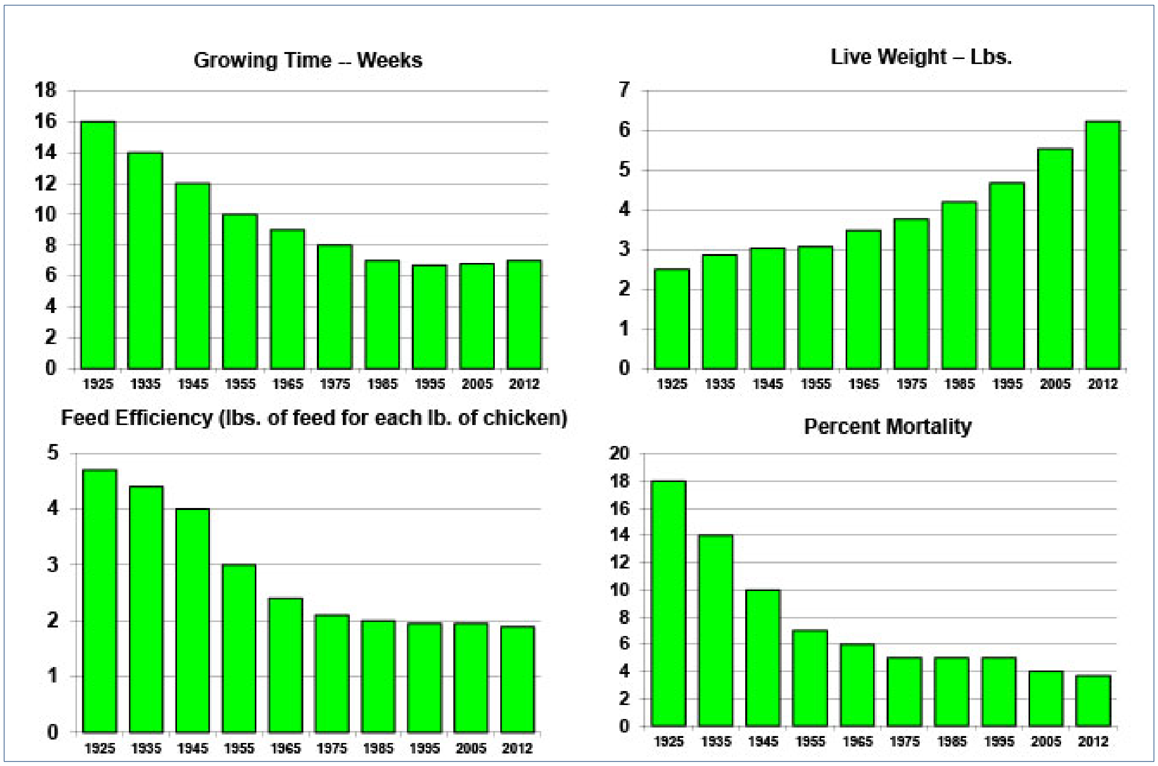

Figure 4. Trends in Broiler Performance.
Research and Innovation Have Led to Dramatic Progress in Broiler Performance
Source. University of Georgia. Prepared by Georgia Poultry Federation

A final trend worth noting in the Georgia broiler industry is that the types of products being sold by wholesalers are changing. In 1965, most chickens were sold whole while fewer than 30% were sold as cut-up parts or further processed. Since the start of this millennium, only about 10% of broilers are being sold whole while 40% are being sold cut-up and 50% are being sold further processed (Figure 5). This trend suggests that consumer preference has changed dramatically over time, with more people buying cut-up and value-added poultry products such as chicken nuggets, wings, etc. rather than whole chickens.

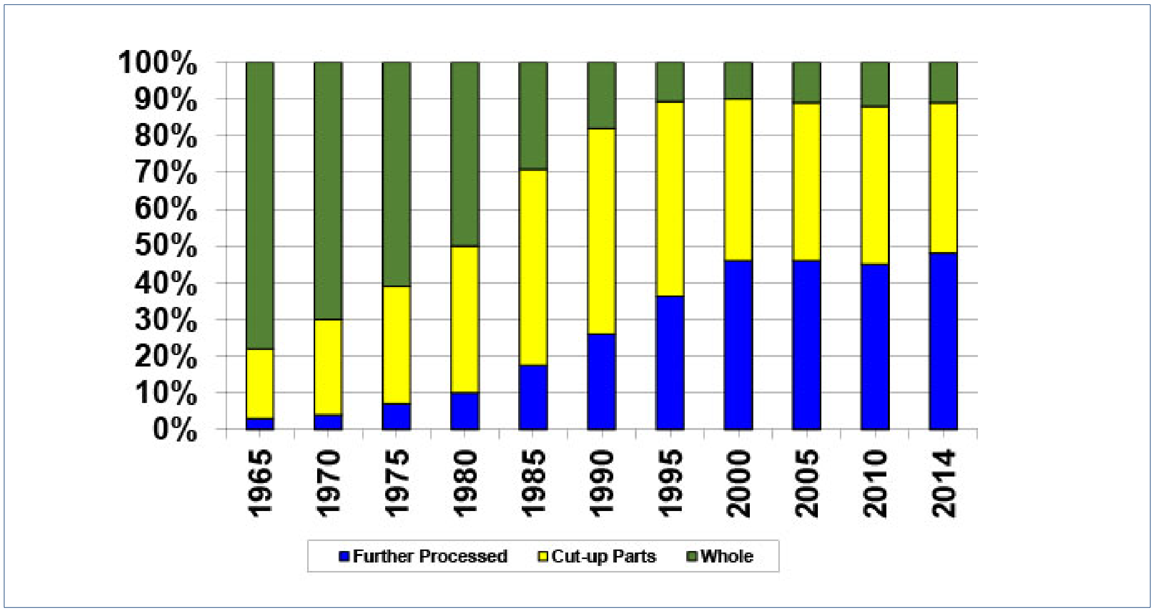

Figure 5. Trends in Poultry Product Sales
The Georgia Poultry Industry Continues to Develop New Value-Added Products

Source. USDA & National Chicken Council (2014 Forecasted) Updated July 2014. Prepared by Georgia Poultry Federation

Georgia's Role in the Global Broiler Market

The U.S. poultry industry is the world's largest producer and second-largest exporter of poultry meat after Brazil (U.S. Department of Agriculture, Economic Research Service 2012). According to the U.S. Department of Agriculture (USDA), U.S. broiler production reached 8.22 billion broiler chickens in 2013 with a total live weight of 50.6 billion pounds (U.S. Department of Agriculture, National Agricultural Statistics Service 2014). Of the 49,655,600 pounds of broiler meat produced in 2012, Georgia was responsible for more than 15% of it at 7,625,000 pounds. Every other top producing state of broiler meat produces less than 6,000,000 pounds (USDA Poultry – Production and Value 2013). As the country's top producer of broiler meat, Georgia is a significant player in determining how much gets exported into the world market, particularly to Mexico and Canada (USDA Livestock and Poultry: World Markets and Trade 2014).

The Georgia poultry industry also contributes to the state and national economy through the export of poultry products. According to the USA Poultry & Egg Export Council (USAPEEC), 2013 was a record-setting year for exports of U.S. chicken and turkey. Combined export value climbed to $5.527 billion, 1.3 per cent higher than 2012, while export quantity was 4.1 million metric tons, up one per cent (World Poultry 2014). Georgia exported approximately 539,600 metric tons of broiler chickens valued at $685 million in 2013 (U.S. Department of Agriculture, Foreign Agricultural Service 2014). These figures represent 15% of total U.S. broiler exports of 3.64 billion metric tons valued at $4.62 billion.

Georgia is strategically located for the export of goods because it is home to the Port of Savannah which moved 32 percent of the total U.S. waterborne poultry exports (USDA Agricultural Marketing Service 2013). The recent passage of the Water Resources Reform and Development Act of 2014 will allow the deepening of the Savannah Harbor as proposed in the Savannah Harbor Expansion Project (SHEP) (Georgia Ports Authority 2014). This will certainly provide greater opportunities for the export of poultry produced in Georgia.

Factors Affecting Georgia Broiler Exports

Factors that have contributed to U.S. broiler meat exports include increased efficiency in domestic production, income and population growth in domestic markets, shifts in currency exchange rates, trade policy and trade conflicts, and relative price changes for other meats (Davis et al. 2013).

Increased exports of poultry also means increased production which translates into increased use of corn and soybean for poultry feed. Corn and soybean farmers and allied industries therefore derive economic benefits from poultry farmers—a vital partnership that boosts the local and national economies. In general, exports from the United States are predicted to remain virtually unchanged as shipments to top markets such as Mexico and Canada remain strong (USDA Livestock and Poultry: World Markets and Trade 2014). Global feed prices impacts how much it costs to raise chickens, so they directly impact the cost of production. At the same time, the success of the poultry industry promotes the success of the feed industries: it is a mutual, symbiotic relationship.

Implications for Georgia's Agricultural Sector and State Economy

The 2nd Congressional District of Georgia is the largest district in Georgia by size, encompassing all or parts of 29 counties in Georgia. The region is mostly rural and its lifeblood is agriculture. Companies that produce and process chicken are an integral part of the economy in this district, employing as many as 4,469 people directly through positions such as raising the chickens and handling the equipment for processing poultry. These companies also generate an additional 6,424 jobs in supplier and ancillary industries. Companies in these industries supply goods and services to the industry, such as transporting feed to the farms and providing veterinary care for the animals (Dunham, J. and Associates 2012) (Table 1).

Table 1. Economic Impact of the Chicken Industry in the 2nd Congressional District of Georgia

	Direct	**Supplier**	**Induced**	**Total**
Jobs	4,469	4,162	2,262	10,893
Wages	$161,338,800	$242,504,000	$98,409,000	$502,251,800
Economic Impact	$1,096,039,900	$861,223,800	$289,959,500	$2,247,223,200

The jobs the poultry industry provides and the taxes it pays to the federal and state government contribute to the wellbeing of the economy as a whole. In 2011, the poultry industry was responsible for as much as $2.25 billion in total economic activity throughout 2nd Congressional District, creating or supporting as many as 10,893 total jobs. The broader economic impact flows throughout the economy, generating business for firms seemingly unrelated to the chicken industry. Real people, with real jobs, working in industries as varied as banking, real estate, accounting, and even printing all depend on the chicken industry for their livelihood.

In addition to creating jobs, the poultry industry also generates sizeable tax revenues. In Georgia, the industry and its employees pay about $2.08 billion in federal taxes and $1.30 billion in state and local taxes (Dunham, J. and Associates 2012) (Table 2).

Table 2. Taxes Generated In Georgia

Tax Impact	Business Taxes
Federal Taxes	$2,082,422,100
State and Local Taxes	$1,304,696,700
Total Taxes	**$3,387,118,800**

The University of Georgia (2012) estimates the annual economic impact of the poultry industry from all activities from farm to processing to be $28 billion per year. In fact, the poultry industry provides jobs to over 100,000 Georgians (Georgia Poultry Federation 2014). These jobs generate revenues for various allied industries and businesses such as suppliers of food, shelter, clothing, and consumer services.

On an average day, Georgia produces 29 million pounds of chicken, 6.3 million table eggs, and 5.5 million hatching eggs (University of Georgia 2012). Georgia has 105 counties that each produce over $1 million worth of poultry annually. Of these, 59 counties have one or more facilities for broiler processing, fowl processing, further processing, breeding, egg packing, egg hatching, feed milling, and by-products processing (University of Georgia 2012). Major poultry processors based in Georgia include Gold Kist, Fieldale Farms, Claxton, Mar-Jac, and Cagle's. Other companies such as Tyson, Con-Agra, and Continental Grain are based outside Georgia but have operations in the state (New Georgia Encyclopedia 2014).

Conclusion

Georgia may be well known for its peaches, peanuts, and pecans, but poultry is certainly the biggest of the four “P’s” in terms of its major contribution to the local economy and global trade. Georgia is expected to continue leading the nation in poultry production and exports, thanks to the hard work and dedication of the citizens of Georgia to produce safe, wholesome, and top quality poultry products for domestic and foreign consumption**.**

Acknowledgments

The authors would like to thank Mike Giles of the Georgia Poultry Federation and Dr. Renan Zhuang and Toby Moore of the USA Poultry & Egg Export Council for providing U.S. and Georgia poultry production data, graphs, and economic analyses.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Shocks to a Trading System: Northeast Asia Poultry Trade and Avian Influenza[1]

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Abstract

Japan and South Korea, net importers of chicken meat, experienced high-pathogenic avian influenza (HPAI) in their domestic broiler populations and faced HPAI outbreaks in some of their principal suppliers in the last two decades. Both countries banned imports of frozen chicken meat from China and Thailand, beginning in 2004. Japanese data show that there was a structural break in import behavior at that time. Rotterdam models are estimated for Japan before and after the break and for Korea from 2005-2013. Results show that China and Thailand competed mostly with each other in the latter period, dividing up the cooked meat trade with few substitution effects evident with other suppliers. Brazil's exports dominate Japan's frozen chicken imports. Imports of both Korea and Japan have been rising. Imports from Brazil and China show the most elastic response to increased import expenditure, suggesting that the share of both countries in East Asian imports could grow in the future.

Keywords: chicken meat trade, Rotterdam model, avian influenza

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[1] The views expressed here are those of the authors, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

Introduction

Japan and South Korea, neighboring countries in Northeast Asia, illustrate interesting changes in the market for broiler meat in the last two decades. Import supplies to these major importing countries have changed profoundly in product type and origin as avian influenza (AI) has affected broiler flocks around the world. Both countries have integrated, modern production of broilers, using imported feedstuffs. Demand for broiler meat has been increasing in both countries (USDA-FAS-PS&D 2014). Domestic production supplies all the demand for fresh and chilled chicken meat, while imports compete strongly with domestic products for frozen and processed chicken demand (Obara 2014; Choi and Myers 2014). Japan is the world's second-largest importer of broiler meat, by value and quantity, and South Korea is the eighth-largest importer (Global Trade Atlas 2015).[2] The two countries export little poultry meat. Northeast Asia, like other parts of Asia, has a consumer preference for 'dark' meat—legs, wings, etc.—as opposed to 'light' meat from the breasts. This naturally complements demand in North America, where breast meat has been preferred, and forms one basis for trade. Labor costs in Northeast Asia are high relative to other parts of the world, and the use of lower-cost labor in the rest of Asia and in South America to produce de-boned broiler cuts and processed chicken products has formed another basis for trade (Dyck and Nelson 2003). Poultry disease, especially AI, has complicated domestic production and trade in the last two decades.

Sanitary regulations strongly condition the trade in frozen broiler meat. Japan and South Korea require that exporting countries meet production, processing, and shipment standards before allowing imports. Until 2005, for example, South Korea did not recognize Brazil's standards, and trade was thus not possible (Phillips and Cheung 2005). Disease outbreaks interrupt normal trade, and, in particular, AI has affected the imports of Japan and South Korea. Both countries banned imports from several countries after outbreaks of highly pathogenic avian influenza (HPAI) in the last 20 years. Finally, disease outbreaks in Japan and South Korea affect those countries' own ability to produce domestic broiler meat. Serious outbreaks of HPAI occurred in both countries in the last 20 years (Figure 1).

Demand for processed broiler meat serves consumers' desire for convenience and variety, both in home meal preparation and in fast food restaurants. Processing can be done either in the country or outside. Processing in Japan and South Korea relies heavily on imports of frozen broiler meat (Obara 2014; Choi and Myers 2014). Domestic processed broiler products compete directly with imported processed products. Imports of processed (or cooked) broiler meat thus can be seen as substitutes both for imports of frozen meat and for domestic production of processed meat. General sanitary regulations apply to processed meat imports. However, diseases present in fresh, chilled, or frozen broiler meat are killed through heat treatment in processing the meat. Thus, processed meat imports are generally not blocked when HPAI or other diseases break out in exporting countries.

[2] For the United States, South Korea was the 10th-largest export market for chicken meat in 2014 by value, and 13th-largest by quantity. Japan was the 19th-largest by value and the 28th-largest by quantity. Together, the two markets represented about 3 percent of U.S. chicken meat export value in 2014.

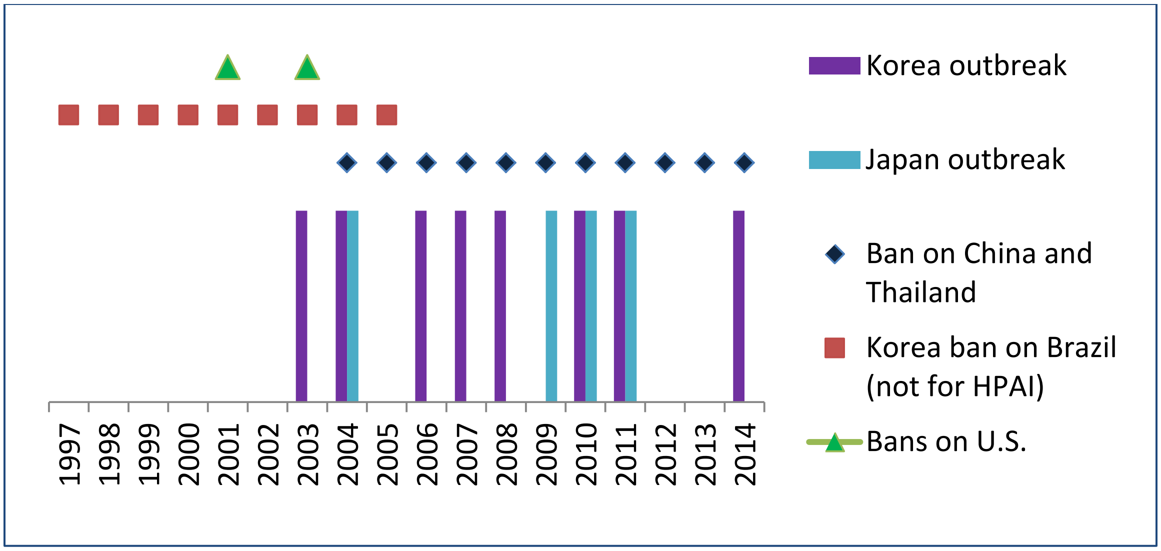

Figure 1. South Korea and Japan HPAI Outbreaks and Trade Bans
Source. USDA-FAS, Selected Gain Reports.

The ability to switch to some extent between exporting frozen and processed broiler products helps explain the continuation of export trade by Thailand and China, two major broiler-exporting countries in Asia (USDA-ERS-PS&D 2014). Relatively low Thai and Chinese labor costs apparently support the ability of firms to export into the global market. Cutting up and deboning fresh chicken is labor-intensive, and even more labor is needed to process broiler cuts into various cooked products.

HPAI outbreaks in 2004 severely affected exports by China and Thailand (Figure 2). Exports recovered to some extent, with Thai exports exceeding pre-2005 record levels in recent years. Both China and Thailand have exported primarily processed broiler meat since 2004 (Preechajarn 2014; Scott, Duerr, and Zhang 2014). However, Thailand regained the right to export frozen meat to the European Union in 2012, and begun exporting frozen meat to Japan again in 2014 (Preechajarn 2012; Obara 2014).

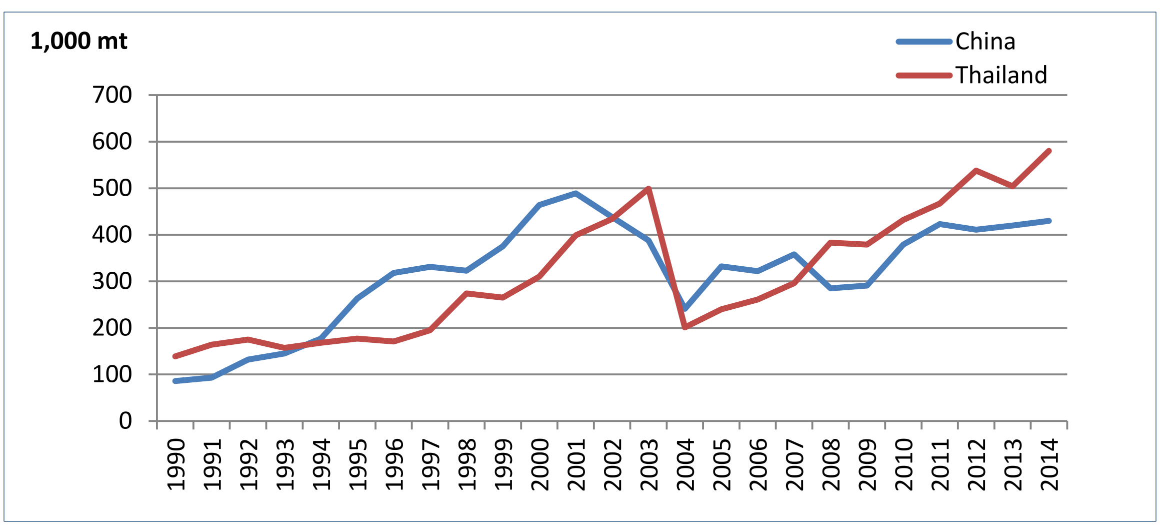

Figure 2. Broiler Meat Exports of China and Thailand
Source. USDA-FAS, PSD Database 2014. September 26.

Imports have provided 32-40 percent of Japan's broiler meat supply since 1995 (USDA-ERS-PS&D 2014). The frozen imports increasingly have been dominated by Brazil, which supplied over 93 percent of Japan's imports in the frozen cuts category (HS020714) in 2013. The United States was a distant second source of imports. Thailand's re-entry into the frozen market in 2014 is expected to provide a new source of competition. Over time, Japan's broiler meat imports have shifted toward processed, or cooked, meat (Figure 3). In cooked meat (HS160232), China and Thailand have competed for the largest import flow into Japan. China and Thailand supplied 50 percent and Thailand 49 percent, respectively, of Japan's cooked chicken meat imports in 2013 (Figure 4).

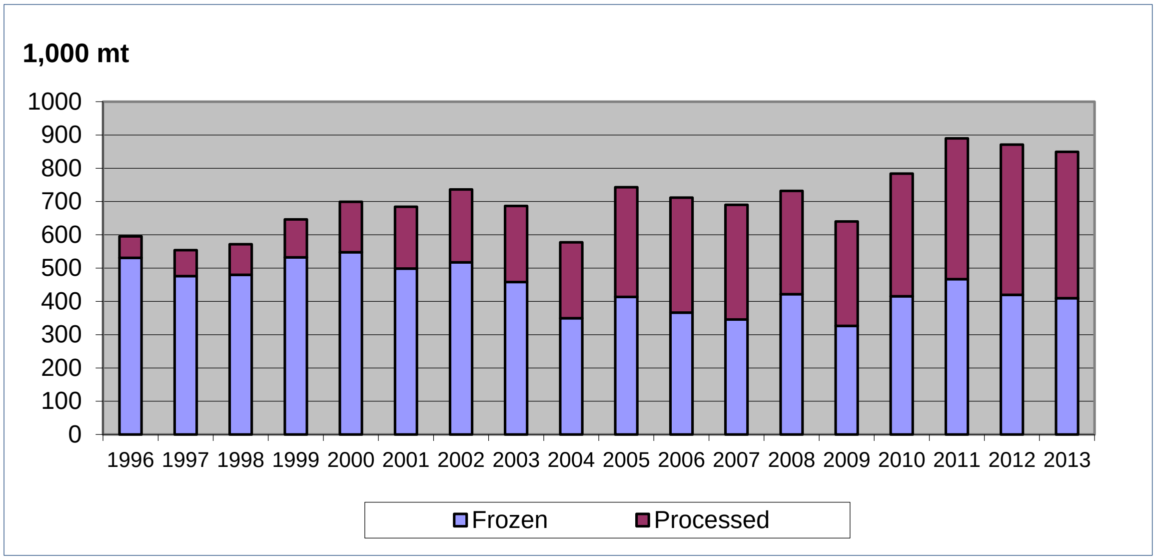

Figure 3. Japan Broiler Meat Imports
Source. ERS data using World Trade Atlas, 2014.

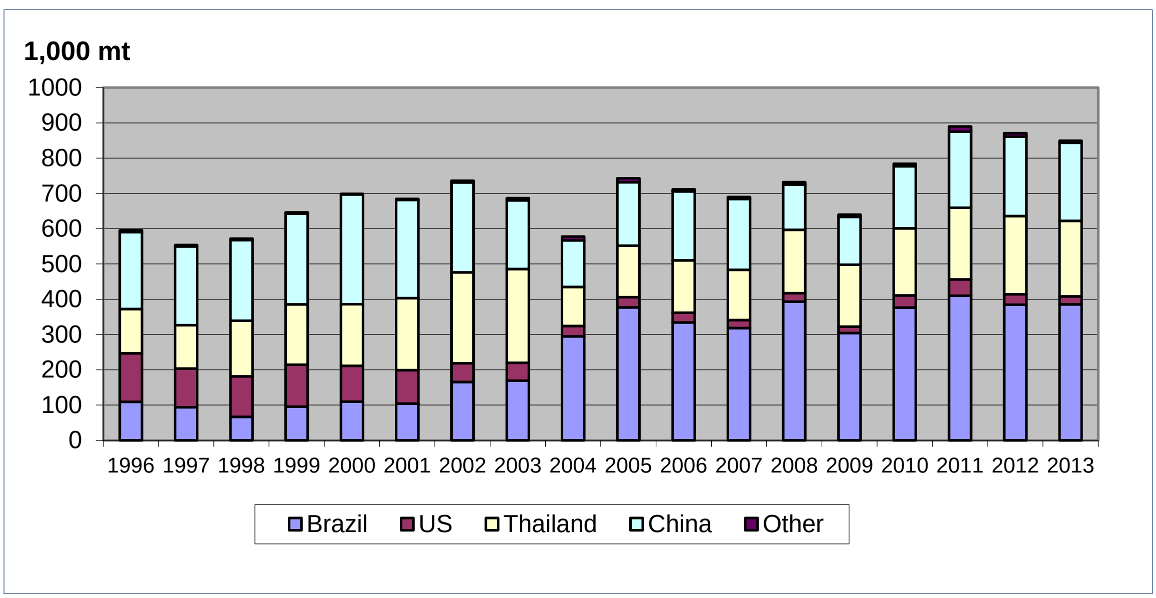

Figure 4. Japan Poultry Meat Imports
Source. ERS data using World Trade Atlas, 2014.

South Korea’s import patterns differ from those of Japan in some respects. Imports are less important, varying between 10 and 18 percent of total supply since 1999 (USDA-ERS-PS&D 2014). Processed meat imports are a lower share of imports than in Japan, about 13 percent of total imports, in quantity terms, in recent years, and about 20 percent of import value (Figure 5). Frozen imports from Brazil now supply the majority of Korean imports, but, unlike Japan, imports from the United States maintain a large share—36 percent in quantity and 24 percent in value. Thailand is the supplier of most of Korea’s imports of processed meat, with China a distant second, unlike the Japanese pattern of nearly even competition. Finally, again unlike Japan, the EU is a consistent exporter of frozen broiler meat to South Korea (Figure 6).

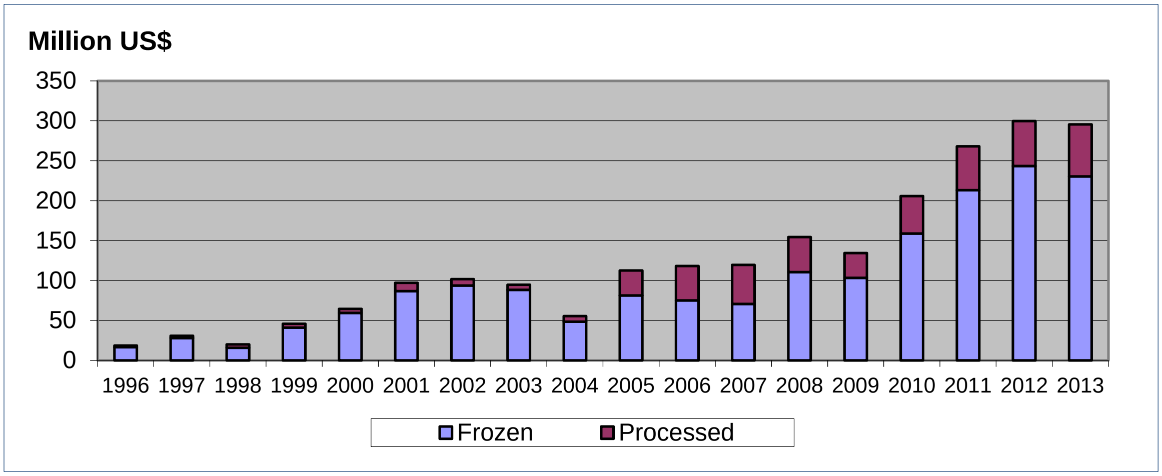

Figure 5. South Korea Broiler Meat Import
Source. ERS data using World Trade Atlas, 2014.

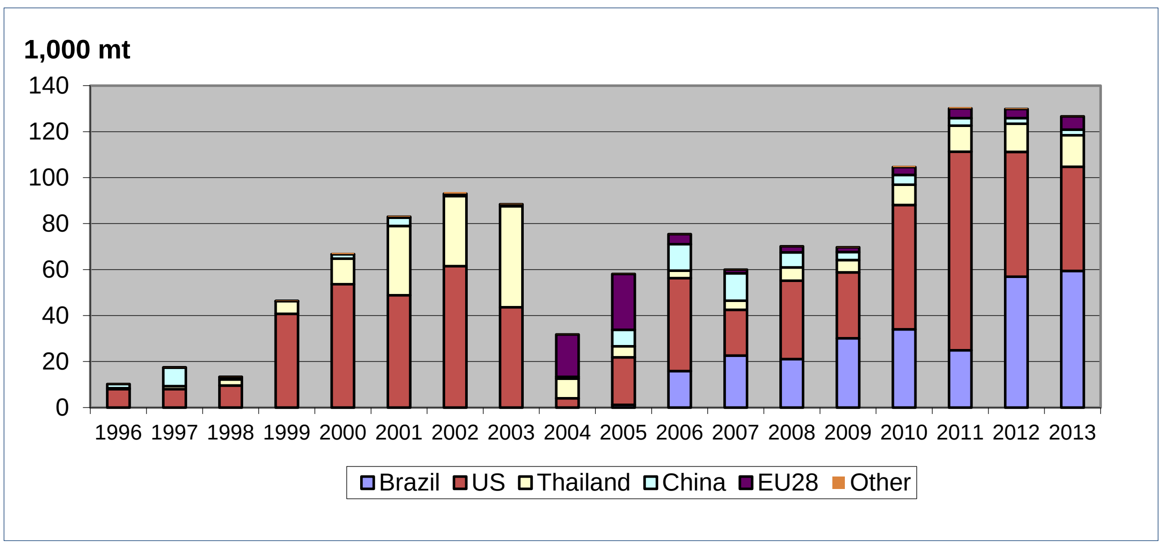

Figure 6. South Korea Poultry Meat Imports
Source. ERS data using World Trade Atlas, 2014.

The East Asia broiler market is based on a relatively homogeneous product, the modern broiler chicken, raised in similar ways in the exporting and importing countries. The underlying preference for broiler meat is for legs and other dark meat in both Japan and South Korea (Obara 2014; Choi and Myers 2014).

Both Japanese and South Korean broiler import markets dipped sharply in 2004 as HPAI outbreaks roiled markets. South Korea's import contraction was more pronounced, likely because the range of possible suppliers did not include Brazil in 2004, while Brazil (not affected by HPAI) was already a large supplier to Japan, and could substitute for suddenly-absent imports from Asian suppliers.

In this article, we test the competitive position of the exporting countries in the Japanese and Korean markets. A particular question is the degree of competition between Thai and Chinese cooked products with uncooked products from other exporters, after HPAI outbreaks led to the ban on frozen chicken imports from Thailand and China. Import behavior in Japan is compared, before and after the ban on Thai and Chinese frozen products. Import behavior in Japan and South Korea is compared, after the bans were imposed. Taha and Hahn (2011) found significant changes in the kinds of meat imported by Japan, before and after major disease outbreaks. This study looks at the changes in origins for one meat type, poultry, in the wake of HPAI outbreaks, and examines whether inter-country competition for Korean and Japanese imports intensified or otherwise changed.

The article next reviews some pertinent literature on AI and trade. Then the Rotterdam approach to modeling import demand is explained, and the data for the variables are documented. Results are presented and discussed for each of the three models estimated (Japan, 1996-2003; Japan, 2004-2013; and South Korea, 2005-2013). Inferences revealed by the estimation are highlighted and implications from them discussed in the concluding section.

Related Studies

This study focuses on a period in which AI was an important problem for poultry production and world poultry trade. While other studies have analyzed the effects of AI outbreaks on poultry trade, no study, to our knowledge, has estimated price and expenditure elasticities before and after an outbreak for Japan and South Korea import demand for poultry. Wieck, Schlueter, and Britz (2012) examined the impact of avian influenza related regulatory policies on poultry meat trade and welfare and found that significant trade diversion took place in countries that experienced an AI outbreak. Their findings also suggested that a trade ban is not the most appropriate measure to resolve the spread of the AI virus. Taha and Hahn (2011) analyzed HPAI impacts on Japan's import demand for cooked and uncooked poultry, beef, pork, and other meats. They discovered that after HPAI and Bovine Spongiform Encephalopathy (BSE) outbreaks, Japan's import demand for meat shifted toward rising demand for cooked poultry and pork meats, and declining demand for uncooked poultry, beef, and other meats. Taha (2007) also investigated how HPAI has affected world poultry meat trade. His findings suggested that the consumers' fear of infection has affected poultry consumption in many countries, causing a reduction in domestic prices, production, and poultry meat exports.

Understanding consumer response to HPAI outbreak is important when predicting impacts within the poultry market. Mu and McCarl (2010) evaluated how consumers' consumption patterns are affected by AI media coverage. Their findings suggested that AI media coverage had a positive effect on poultry demand in the short –term, while BSE had a negative effect on beef demand. Beach et al. (2008) examined the effects of avian influenza news on consumer purchasing behavior. Their estimated poultry demand, as influenced by the volume of newspaper reports on AI, reveals the magnitude and duration of newspaper articles' impacts on consumers' food choices. A significant number of news reports on AI have given rise to large reductions in poultry purchases.

Disease outbreaks in red meats, particularly pork and beef, have had similar impacts on trade. Yang and Saghaian (2010) looked at what happens to U.S. pork exports when foot-and-mouth disease (FMD) is discovered in other countries importing U.S. pork. Findings reveal that FMD outbreaks in foreign countries have a positive impact on U.S. pork exports. Jin and Koo (2003) examined the effects of BSE outbreak in Japan on the import demands for U.S. beef in Japan and South Korea. Findings show that BSE outbreak in Japan influenced Japanese meat import demand from the U.S., but not South Korean meat import demand.

Similarly to Taha and Hahn (2011), this study will evaluate the impact a trade restriction (shock) has on chicken imports. More specifically, the study will explore the impacts of Japan's restriction on chicken imported from China and Thailand and competitive relationships among suppliers in the neighboring Japanese and Korean markets.

Rotterdam Model

Demand for chicken meat imports is modeled as the third stage of consumer choice to allocate expenditures. In the first stage, following the findings of Chung et al. (1993) and Seale et al. (1992), chicken meat expenditure is assumed separable from expenditures on other groups of goods. In the second stage, expenditure for chicken meat is allocated between domestically produced and imported chicken meat. Finally, expenditure on chicken meat imports is allocated among import sources. In this study, we estimated the import demand for chicken meat (both uncooked and cooked) by source according to the importing country. By incorporating the differential approach to consumer demand, it is possible to derive the conditional demand equation for imported chickens by source. Let $W^*_i = W_i/W_g$ and $\alpha^*_i = \alpha_i/\alpha_g$, where W^*_i is the (conditional) trade share of imported chicken meat from country I, W_i is the budget share of imported chicken meat from country I, C_g is the imported chicken meat group such that $W_g = \Sigma_{i \epsilon Cg} W_i$ is the budget share of the group C_g, and α_i represents the marginal share of imported chicken from country I. Following Weatherspoon, Davis, and Olorunnipa (1999) and Weatherspoon and Seale (1995), the conditional demand equation for imported chicken by source can be written as:

$$(1) \quad W^*_i\, d(\log q_i) = \alpha^*_i\, d(\log Q_g) + \Sigma_{i \epsilon Cg}\, \delta^*_{ij}\, d(\log p_i)$$

where p_j is the price of imported chicken meat from sources j, q_i is the quantity of imported chicken from I, δ_{ij}s are (conditional) Slutsky price parameters, and $d(\log Q_g) = \Sigma_{i \epsilon Cg} W^*_i\, d(\log q_i)$ is the Divisia quantity index for C_g (Theil and Clements, 1987). The d in equation (1) is a derivative for discrete changes from one month to the next. In this analysis, we assume that α and the δ_{ij}s are constant so that we can obtain the conditional absolute version of the Rotterdam model (Theil and Clements, 1987). Two Rotterdam models were used to analyze chicken meat imports by Japan and South Korea. The models were estimated without imposing any restrictions and with homogeneity restrictions imposed. Laitinen's (1978) exact homogeneity test did not reject homogeneity at the 0.05 significance level for the Japan and South Korea models.

Symmetry restrictions were tested using likelihood ratio tests comparing the symmetry and homogeneity restricted models to those of the homogeneity restricted ones (Bewley 1986). Symmetry and homogeneity could not be rejected for either the Japanese or Korean models at the significance level of 0.05.

Two Rotterdam models (uncooked and cooked chicken meat combined) are analyzed for two sizable import markets for U.S. broiler meat using Time-Series Processor (TSP). Monthly observations from 1996 to 2013 are analyzed for Japan and 2005 to 2013 for South Korea. Price and expenditure elasticities were estimated for each market. The elasticities estimated reflect the market for imported chicken meat. Based on assumed separability of consumer decision-making, domestic chicken meat and other consumer goods are not part of the analysis. Expenditures in this analysis are the total value of imported chicken meat. Import unit values are treated as prices in the analysis.

Data

The data are import expenditures, quantities, and import unit values obtained from a proprietary database of official Japanese and Korean import statistics (GTIS 2014). The original Korean data are in U.S. dollars, and have not been converted. The Japanese data are in Japanese yen. The data represent the major exporters. In the case of Japan, remaining imports from minor exporters were aggregated into a Rest of World (ROW) variable. For Korea, imports from other countries were omitted from the analysis, because there were too many months with no trade, and the aggregate volume of the imports was always quite small.

Results

To measure the impact of the trade ban, a preliminary test was conducted to determine if there was structural change after Japan imposed trade restrictions against the U. S., Thai, and Chinese poultry exports in 2003 and 2004. The test statistics[3] reveal that there was a structural break in chicken trade flows between the periods January 1996 to December 2003 and January 2004 to December 2013, corresponding to the events in the timeline in Figure 1. Due to these findings, estimation of Japan's chicken trade is divided into two separate data periods: before and after the restriction was enforced.

The Japanese Chicken Imports before Restrictions (1996-2003)

In the Japanese market, the major competitors are Brazil, China, Thailand, and the United States. Table 1 shows the price and expenditure elasticities for the Japanese market which are the conditional Slutsky price parameters for the Rotterdam model (symmetry and homogeneity imposed). Three of the five own-price parameters had the expected negative sign and were significantly different from zero (at the significance levels of 0.01 and 0.10) with the exception of ROW and U.S. Of the four countries analyzed, China and Brazil own-price elasticities have

[3] We used the dummy variable approach to test if the parameters were significantly different in the two time periods. The likelihood ratio test indicates that the parameters were different. Test Statistic: 269.497, Upper tail area: 0.0000.

the greater impact and more significant role in explaining changes in Japanese imports of chicken meat than do the Thai, U.S., or ROW own prices. A 1% change in the own-price of China and Brazil chicken meat will cause Japan's import demand of chicken meat from that country to increase or decrease by almost 1%. A 1% change in the Thai own price leads to a change of 0.63% in imports from Thailand.

Table 1. Japan's Price and Expenditure Elasticities for Chicken Imports before the Restrictions were Applied on U.S., Thailand, and China (1996-2003).

	ROW	Thailand		U.S.		China		Brazil		Exp. Elasticity	
ROW	–0.277	0.006		– 0.015		0.005		–0.003		0.704	***
	(–1.331)	(0.414)		(– 0.705)		(0.579)		(0.114)		(1.988)	
Thailand	0.336	–0.628	***	–0.301		0.487	***	0.274		0.465	***
	(0.414)	(–4.179)		(–1.597)		(6.472)		(0.909)		(7.578)	
U.S.	–0.296	–0.107		–0.122		0.194	***	–0.202		0.601	***
	(–0.705)	(–1.597)		(–0.535)		(2.757)		(–0.879)		(3.297)	
China	0.320	0.611	***	0.682	***	–0.994	***	0.899	***	1.250	***
	(0.579)	(6.472)		(2.757)		(–6.293)		(2.106)		(11.532)	
Brazil	–0.083	0.118		–0.360		0.309	***	–0.967	*	1.858	***
	(–0.114)	(0.909)		(–0.879)		(2.106)		(–1.770)		(5.634)	

Note. T-Statistics are in parentheses. *** Represent significant levels at 1%* Represent significant levels at 10%.
Source. Authors' calculation using the GTIS data.

In the Japanese market, the Slutsky cross-price elasticities suggest that most of the major markets exporting chicken to Japan before the HPAI outbreaks served as substitutes for one another within the Japanese market place (Table 1). Of the 20 cross-price elasticities estimated, six are statistically significant. All six significant cross-price elasticities suggest a substitute relationship (plus sign). The eight cross-price elasticities involving the ROW do not significantly differ from zero. This is unsurprising, since the ROW is an aggregate of a shifting set of minor exporters, and strong substitution effects with the major exporters might not be occurring, or might be masked by sporadic entry and exit of minor exporters. The largest substitution effect occurs between Brazil and China. A 1% increase in the Brazil chicken price will cause Japan to increase imports of China chicken by .90%, which suggests an almost proportional change in quantity imported to a change in price. The U.S. and China as well as Thailand and China are also competitors in the Japanese market; a 1% increase in the price of U.S. chicken would cause Japan to import 0.68% more of China's chicken, while a 1% increase in the price of Thailand's chicken would cause Japan to import 0.61% more of China's chicken. Thailand, Brazil, and the U.S. also would benefit if China should increase the price of its chicken exported to Japan.

The expenditure elasticities are all positive as expected and statistically significant at the 0.01 level (Table 2). Brazil and China expenditure elasticities estimates suggest that the two are elastic and growing overall import demand has a strong impact on Japan's chicken imports from those countries. If the Japanese market expands its expenditure on imported chicken by 1%, Thailand and China's market shares will increase more than proportionately, 1.86% and 1.25%, respectively. Given the same scenario, Thailand, ROW, and U.S. market shares would increase by less than 1%.

The Japanese Chicken Imports after Restrictions (2004-2013)

Table 2 displays Japan's price and expenditure elasticities for chicken after a restriction was enforced on the U.S., Thailand, and China chicken exports. This impediment to trade was short lived for the U.S., lasting only six months, but is still in place for China and was in place through 2013 for Thailand. The own-price elasticities shown in Table 2 are all negative with four of the five being statistically different from zero. After the restriction, the U.S. and the ROW own-price elasticities are elastic (1.14 and 1.99, respectively) and statistically significant, which is different from the elasticities estimated before the restriction. A moderate decrease in U.S. and ROW chicken prices would give rise to a more than proportional increase in the quantity of chicken imported by Japan from those countries. Differences are also seen in the own-price elasticities of Thailand, China, and Brazil. Findings suggest that imports from China became more price sensitive than those from Thailand after the restriction, and that imports from Brazil became less sensitive to own-price movements than before the restrictions (Tables 1 and 2). Similar to our study, differences in Japanese import demand elasticities before and after Japan's 2004 HPAI-outbreak and U.S. 2003 BSE-outbreak are also found by Taha and Hahn (2011). Findings show that cooked poultry own-price elasticity (-0.120 to -0.744) and beef own-price elasticity (-0.923 to -1.432) became more sensitive to changes in prices after the outbreak.

Table 2. Japan's Price and Expenditure Elasticities for Chicken Imports after the Restrictions were Applied on U.S., Thailand, and China (2004-2013).

	ROW		**Thailand**		**U.S.**		**China**		**Brazil**		**Exp. Elasticity**	
ROW	–1.993	***	–0.094	***	– 0.066		0.176	***	0.003		0.470	***
	(–7.491)		(–5.827)		(– 0.997)		(9.837)		(0.215)		(2.487)	
Thailand	–2.377	***	–0.537	***	1.700	***	0.889	***	–0.294	*	0.618	***
	(–5.827)		(–2.814)		(2.815)		(5.209)		(–1.768)		(6.063)	
U.S.	–0.126		0.128	***	–1.137	***	–0.010		–0.213		0.807	**
	(–0.997)		(2.815)		(–4.211)		(–0.189)		(–0.457)		(1.971)	
China	4.408	***	0.877	***	–0.137		–1.567	***	0.396	*	0.721	***
	(9.837)		(5.509)		(–0.189)		(–5.660)		(1.903)		(5.934)	
Brazil	0.089		–0.374	*	–0.360		0.511	*	–0.084		1.544	***
	(0.216)		(–1.768)		(–0.456)		(1.903)		(–0.302)		(12.959)	

Note. T-Statistics are in parentheses. *** Represent significant levels at 1% **Represent significant levels at 5% * Represent significant levels at 10%
Source. Authors' calculation using the GTIS data.

Findings suggest a stronger substitution relationship among exporting countries than before the restriction was established. One reason for this stronger substitution across countries after the restriction is that importers may no longer see it beneficial to rely on a single or a few exporting countries to supply chicken meat. The strategy of many suppliers helps importers obtain more competitive chicken prices and it reduces the chances of domestic demands being disrupted for long periods if there is an AI outbreak in one or two poultry exporting countries.

In the Japanese market, China and the ROW chicken products became substitutes as well as the U.S. and Thailand after the restriction. All of the chicken substitutions among countries that existed before the restriction continue to exist except for those between China and the U.S. In addition, Thailand's chicken exports and Brazil chicken exports became complements to each other after the restriction.

Similar to Table 1, the expenditure elasticities in Table 2 are all positive and statistically significant at the 0.01 level. The expenditure elasticities estimated after the restriction are smaller, overall, than those estimated before the restriction. Brazil's expenditure continues to be more sensitive to changes in Japan's expenditure on imported chicken meat than other exporting countries. This is consistent with the increasing share of Brazil in Japan's imports during this period. Findings suggest that China's expenditure elasticity is inelastic and changes in Japan's chicken imports have less of an impact than before the restriction.

As anticipated, the two models yielded somewhat different results. The results after the restriction are statistically stronger than the derived results before the restriction. One reason that the model examining Japanese chicken imports from 2004 -2013 is statistically stronger, is due to the sustained growth in world poultry trade during this period. Brazil and the U.S., the world's largest poultry exporters experienced exceptional growth within this period of consideration. Between 2001 and 2012, Brazilian exports more than doubled, increasing from 1.2 million metric tons (mmt) to 3.5 mmt. Total U.S. broiler meat exports grew by 31 percent between 2001 and 2012, and only by 9.2 percent between 1997 and 2002 (Davis et al. 2013). In addition, our results reveal that there was a structural break in chicken trade flows that separated the two periods.

Table 3. South Korea's Price and Expenditure Elasticities for Chicken Imports (2005-2013).

	Thailand		U.S.		EU-28		China		Brazil		Exp. Elasticity	
Thailand	–1 .313	***	-0.167	***	–0.381		0.692	**	0.437	***	0.337	***
	(–3.999)		(–2.447)		(– 0.917)		(1.954)		(7.598)		(3.655)	
U.S.	–0.369	***	–0.928	***	–1.092		0.158		0.940	***	0.827	***
	(–2.447)		(–3.294)		(–1.557)		(0.351)		(5.932)		(4.775)	
EU-28	–0.093		–0.120	***	–0.590		0.275		0.099	*	1.670	***
	(–0.917)		(–1.557)		(–1.128)		(1.325)		(1.686)		(3.505)	
China	0.587	**	0.060		0.959		–2.094	***	0.302	***	1.145	***
	(1.954)		(0.351)		(1.325)		(–3.890)		(2.106)		(4.201)	
Brazil	1.188	***	1.154	***	1.105	*	0.969	***	–1.777	***	1.279	***
	(7.598)		(5.931)		(1.686)		(2.922)		(–11.277)		(11.603)	

Note. T-Statistics are in parentheses. ***Represent significant levels at 1% **Represent significant levels at 5% * Represent significant levels at 10%
Source. Authors' calculation using the GTIS data.

The South Korean Market (2005 - 2013)

Table 3 displays the price and expenditure elasticities for South Korea import demand for chicken. All own-price elasticities are negative as expected and significantly different from zero (at the 0.01 significance level) with the exception of the EU-28. Findings suggest that the Korean market is most sensitive to changes in China's chicken prices. A percentage decrease in China's chicken price will give rise to twice that percentage increase in quantity imported from China. Brazil and Thailand imports were sensitive to own-price movements in the Korean market as well. A 1% change in the own-price of Brazil and Thailand will cause trade (Korea's import demand of chicken from those countries) to increase or decrease more than proportionately. Of the four statistically significant own-price elasticities, the U.S. had the smallest elasticity (but still near -1). Given a 1% change in the U.S. own-price, U.S. imports would have changed by 0.93% in the opposite direction.

Most of the Slutsky cross-price elasticities (14) suggest that the chicken exports from various countries to the Korean market are primarily substitutes. Ten of the 14 cross-price elasticities suggesting a substitute relationship are statistically significant. Of the five major chicken exporting countries, Brazil stands to gain the most in Korea given an increase in other competitors' chicken prices. The largest substitution effects exist between Thailand and Brazil. A percentage increase in Thailand, U.S., EU-28, and China chicken prices will yield a 1.19%, 1.15%, 1.11%, and 0.97% increase in Korea's chicken import from Brazil. U.S. benefits almost proportionally if Brazil were to increases its chicken price by 1% and Thailand gains market shares if China and Brazil were to increase their chicken prices. China gains if Thailand and Brazil were to increase their chicken prices and EU-28 profits only if Brazil's chicken price increases.

In Table 3, findings indicate that the expenditure elasticities are all positive, adhering to economic theory. Each country's expenditure elasticity is significantly different from zero at the 0.01 level (Table 3). If Korea were to expand its chicken import expenditure, the EU-28 would capture the most market share followed by Brazil and China. Findings also suggest that the U.S. and Thailand stand to gain the least of the five chicken exporters and their market shares would increase by less than 1%, given a 1% rise in chicken import value.

Conclusion

Analysis of chicken meat trade data for 1996-2013 for Japan and 2005-2013 for South Korea allows comparison of trade behavior between the two countries and of trade behavior during a period of serious HPAI outbreaks and especially of a ban on frozen exports from two major suppliers.

HPAI outbreaks in China and Thailand ended the exports of frozen chicken meat from those countries to Japan and South Korea, but cooked meat was still exported. The two countries dominate the cooked meat imports of Japan and South Korea, and their trade with Japan and Korea after 2004 can be seen as a good approximation of cooked meat imports, while the trade of other suppliers constituted the frozen imports. A statistical test indicated that the parameter values, as a set, were different before and after 2004, for Japan.

Before 2004, China and Thailand were major suppliers of frozen chicken meat, in addition to some cooked meat. Expenditure elasticities for China and Thailand with respect to Japan's total import value for chicken meat show that the expenditure elasticity for Thailand increased somewhat after 2004, and the expenditure elasticity for China decreased sharply (from 1.25 to 0.72). Own-price elasticity for Thailand fell, while that for China rose. These results do not offer strong indication of a shift in demand as the product switched from mostly frozen to entirely cooked.

However, the cross-price elasticities between China and Thailand rose after 2004, consistent with their position as virtually the only competitors for cooked product trade. Cross-price elasticities with other suppliers in the Japanese market after 2004 were not significant or were negative (indicating complementarity rather than competition), except for the Thai elasticity with respect to the U.S. price. Similarly, for Korean imports, China and Thailand had robust, positive cross-price elasticities, while cross-price elasticities with other countries were 0 or negative, except for Brazil, whose frozen product apparently competes with cooked chicken in that market. Overall, the results support strong competition between China and Thailand for cooked meat imports of

Japan and Korea, and much less competition with other suppliers. The higher expenditure elasticity for Chinese products than for Thai products may indicate that China's share of cooked meat may rise in the future, compared to Thailand's share.

In general, the developments in the two large Asian importing markets, Japan and Korea, in the wake of the HPAI outbreaks show that cooked product imports can successfully replace frozen products. Both Thai and Chinese suppliers were able to make this transition. This could be relevant for other major import markets in the future, if HPAI outbreaks again occur.

In both Japan and Korea, 3 of 5 own-price elasticities exceed 1, since 2005. Trade shares are thus sensitive to price, in general. Expenditure elasticities for most exporting countries are high in both Japan and Korea. However, expenditure elasticities for Thailand are relatively low, suggesting that the Thai share of chicken meat imports could drop in the future.

A rise in Brazil's price has strikingly little impact on its trade with Japan, according to these estimates. The own-price elasticity and the cross-price elasticities are not significant, except with regard to the U.S., in which case complementarity is evident. Brazil's dominance of the frozen meat trade with Japan may continue, since the expenditure elasticity for Brazil is the highest measured for Japan in the post-2004 period. However, the end of the ban on Thai frozen chicken in 2014 (outside the data used here) may bring some new competition for Brazil. In Korea, Brazil's price changes are much more important. The own-price elasticity is high (almost -1.8) and cross-price elasticities are positive and significant. As with Japan, the expenditure elasticity for Brazil is the highest of the exporting countries.

U.S. expenditure (about 0.8) and own-price elasticities (about -1) in the post-AI ban periods in Japan and Korea are quite similar. In both countries, there are few significant cross-price elasticities involving U.S. trade. The U.S. price is quite important for Brazil's trade with Korea, and vice versa. In Japan, the U.S. price affects only Thai imports, while the Thai import price is the only one that affects U.S. trade. U.S. trade with Japan is virtually only in bone-in legs, and this product differentiation may explain the lack of competition involving the U.S. Korea imports more chicken meat from the U.S. than Japan does, but, as with Japan, competition with other suppliers does not appear widespread for U.S. trade with Korea.

Rotterdam models, applied to a segment of trade in Japan and South Korea, appear to provide demand parameters that correspond well to market behavior in a period of considerable turmoil related to HPAI outbreaks. The estimates may be useful in assessing future competition for the chicken meat imports in East Asia.

Firms involved in supplying consumers with chicken meat have the option of importing cooked meat, when AI disrupts the supply of fresh or frozen chicken. The Japanese and Korean experience demonstrates that cooked chicken is a viable alternative to frozen chicken imports.
Policymakers should consider how consumer needs for meat will be met, as policies to deal with HPAI or other animal diseases are formulated. In South Korea, broiler meat consumption dropped below earlier levels in 2004 and 2005 (by 10 percent, in 2004). In Japan, consumption in 2004 was 7 percent less than in 2003. In both countries, these declines were among the most abrupt in the last 20 years. Policies that spell out in advance protocols that can maintain more

supply, such as defining regional markets within supplying countries that can be treated as distinct when addressing disease risk, or that automatically exempt cooked products from import bans, can alleviate consumption shocks. HPAI shocks continue to occur: a 2015 outbreak in the United States and other countries has again affected trade. In response, Korea banned frozen poultry meat imports from the United States (Meatingplace 2015). Results from this study suggest that Brazil will substitute for Korean imports from the United States. If Brazil were also affected, the results indicate that processed poultry meat imports from Thailand and China would rise.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Supplying China's Growing Appetite for Poultry

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Abstract

Exports provide a valuable source of income for the U.S. poultry sector, where the U.S. is the world's second largest broiler meat exporter. Russia, a top market for U.S. broilers, recently declared a one year ban on U.S. agricultural products. To fill this void, China, the United States' leading agricultural trading partner, could be considered as an expanding market for the U.S. poultry industry. In this paper, we explore the potential for U.S. poultry export opportunities by examining China's demand, supply, food safety and trade barriers which affect poultry trade between the two countries. Results indicate that although China may not experience rapid growth in U.S. poultry exports in the short run as it meets Chinese consumers' demand, but that market opportunities exist in the long run as China confronts its supply constraints.

Keywords: China, poultry, exports, food safety, trade barriers

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Introduction

In August 2014, the Russian government announced a one-year ban on agricultural products from the United States. While less than prior years, Russia remains one of the top markets for U.S. broiler exports with 7.5 percent of U.S. broiler shipments sent to Russia on a year-to-date basis in 2014 (U.S. Department of Agriculture (USDA), 2014). In fiscal year 2015, U.S. poultry exports are forecast to decrease by $100 million to $6.1 billion (USDA 2014). Given this decline, and with expected increases in production, U.S. exporters are likely to search for alternative markets for their products.

China, neighbor of Russia, is the largest international market for U.S. food and agricultural products (Figure 1), accounting for nearly 20 percent of all U.S. farm exports. U.S. agricultural exports to China reached a record $26.7 billion in fiscal year 2013 (Gale, Hansen and Jewison 2015; USDA 2014). As discussed in Stuart and Fritz (2013), China has been viewed as the "market of the future" for decades. The future is now, when China overtook Canada as the leading market for U.S. agricultural exports in 2012 and remained so since then.

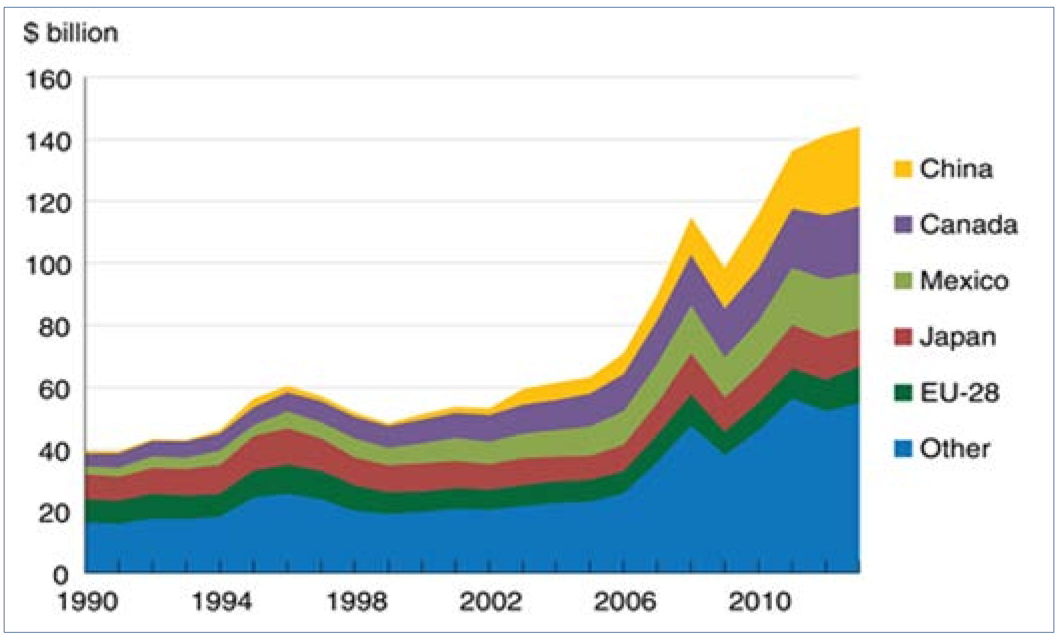

Figure 1. Top Markets for U.S. Agriculture Export
Source. USDA, Economic Research Service using data from U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Database.

Given China's dramatic impact on U.S. agricultural exports overall, it makes sense to consider China as a potential poultry export market, especially after the U.S. poultry sector increased its export market share to China from 12 percent in 2012 to 37 percent in 2013 (USDA-GAIN Report 2014).

The main objectives of this research are to (1) provide an overview of China's continuously evolving marketplace as determined by changing urban-rural demographics, rising incomes and subsequent changing diets including increased demand for poultry; (2) examine policy changes that restrict U.S. poultry trade with China, e.g., use of safeguards and (3) assess food safety issues and how this may create opportunities for U.S. poultry exporters.

Overview of China's Poultry Market

China's Evolving Market-Demand Side

Historically, poultry and eggs were not an important part of the Chinese diet and considered luxury goods for special occasions, e.g., century eggs (Pi et al. 2014). In contrast, China is currently the world's second largest poultry consumer after the U.S. (Figure 2; USDA-FAS-PSD). Chinese per capita consumption of poultry products has increased continuously over the past two decades with rapid income growth (Tables 1 and 2).

Tables 1 and 2 reveal three key points:

- Chinese urban households consume much more poultry than rural households (National Bureau of Statistics of China 2013; Zhou et al. 2014).
- Since 1990, Chinese urban and rural consumers increased their poultry consumption by nearly three times and four times respectively (National Bureau of Statistics of China 2013).
- China's poultry meat consumption grew faster than that of any other meat for both urban and rural households and its consumption share with respect to meat is increasing (National Bureau of Statistics of China 2013 and our own calculations).

These findings again indicate that market opportunities may exist for U.S. poultry exporters to China.

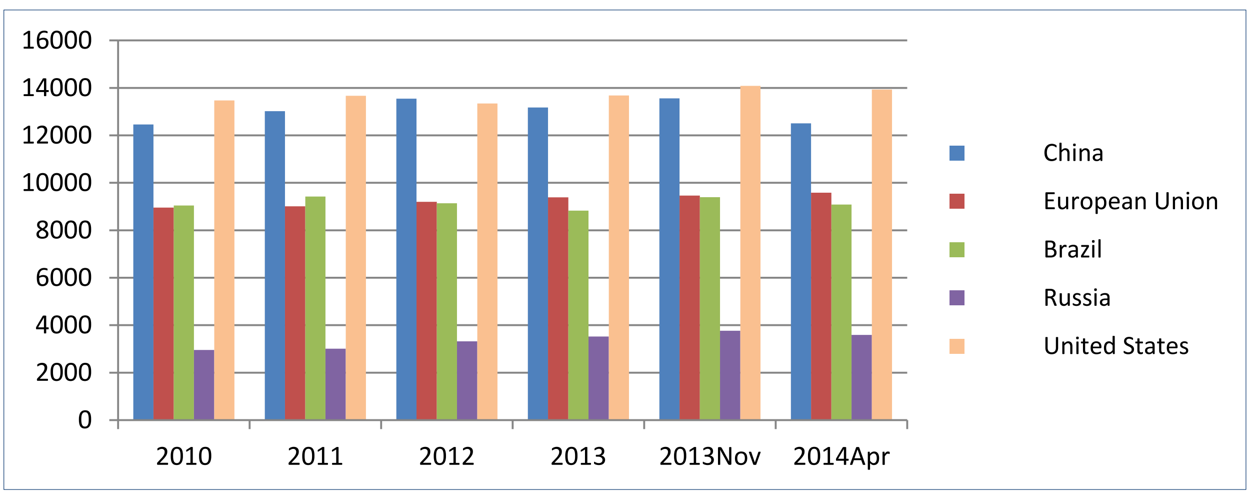

Figure 2. Global poultry consumption by country (1000 metric tons)
Source. USDA-FAS Production, Supply and Distribution Online Database, 2014.

Table 1. China's *Rural* Per Capita Consumption per Year (kg)

Year	Pork	Beef and mutton	Poultry	Eggs and products	Milk and products	Aquatic	Poultry/ Meat
1990	10.54	0.80	1.25	2.41	1.10	2.13	10%
1995	10.58	0.71	1.83	3.22	0.60	3.36	14%
2000	13.28	1.13	2.81	4.77	1.06	3.92	16%
2005	15.62	1.46	3.67	4.71	2.86	4.94	18%
2010	14.40	1.43	4.17	5.12	3.55	5.15	21%
2011	14.42	1.90	4.54	5.40	5.16	5.36	22%
2012	14.40	1.96	4.49	5.87	5.29	5.36	22%

Source. National Bureau of Statistics of China, China Statistical Yearbook 2013.

Table 2. China's *Urban* per Capita Consumption per Year (kg)

Year	Pork	Beef and mutton	Poultry	Eggs and products	Milk and products	Aquatic	Poultry/ Meat
1990	18.46	3.28	3.42	7.25	4.63	7.69	14%
1995	17.24	2.44	3.97	9.74	4.62	9.20	17%
2000	16.73	3.33	5.44	11.21	9.94	11.74	21%
2005	20.15	3.71	8.97	10.40	17.92	12.55	27%
2010	20.73	3.78	10.21	10.00	13.98	15.21	29%
2011	20.63	3.95	10.59	10.12	13.70	14.62	30%
2012	21.23	3.73	10.75	10.52	13.95	15.19	30%

Source. National Bureau of Statistics of China, China Statistical Yearbook 2013.

Drivers of Chinese poultry demand include income growth in both urban and rural areas, changing diets and demographic changes–growing population and urbanization. These drivers will be discussed below.

Income Growth of Urban and Rural Households

Since 1990, China's urban and rural residents experienced significant income growth by nearly 18 times and 11 times, respectively (Figure 3). In other words, per capita urban income doubled every ten years. This income growth directly affected Chinese consumption of meat products.

As documented in Bingsheng and Yijun's 2008 publication that reviewed numerous Chinese poultry demand studies, although specific results differ, researchers agree that the effect of income on Chinese poultry demand is large. The average income elasticity for poultry meat is 0.7 for China's urban households and 3.12 for rural households (Bingsheng and Yijun 2008).

More recently, Zhou, Yu, Abler and Chen (2014) conducted a meta-analysis of meat and cereal demand for China. They analyzed 143 income elasticity estimates for grains and 240 for meats from 36 primary studies. Results showed that income elasticities declined as per capita income increased, with the exception of wheat. Additionally for food demand forecasts that use income elasticities for projections, their results showed a gap between forecasts using time-varying versus constant income elasticities.

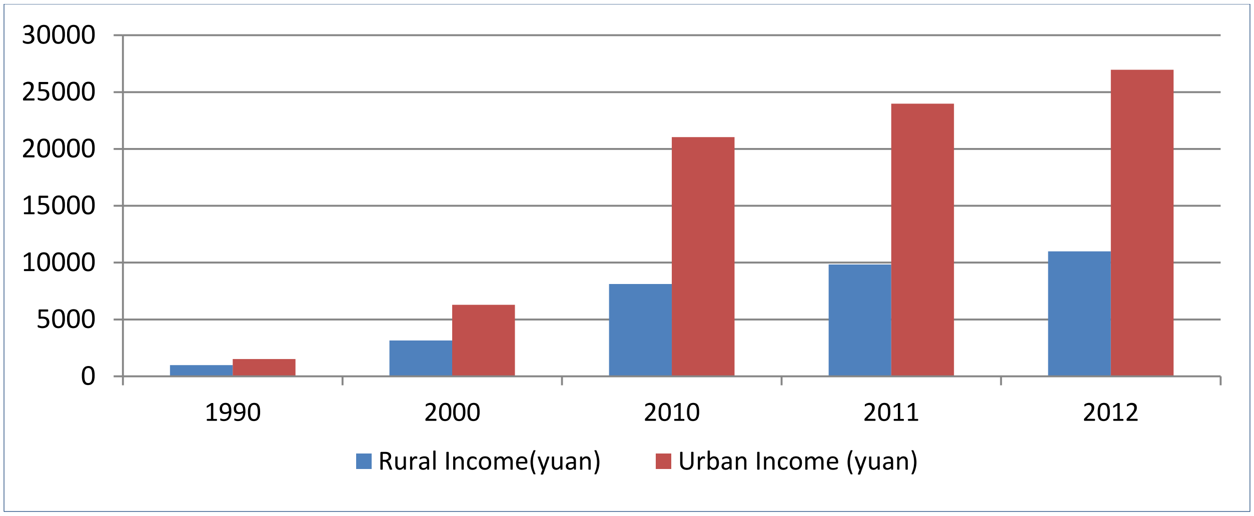

Figure 3. China's Urban and Rural Income
Source. National Bureau of Statistics of China, China Statistical Yearbook 2013.

Further results from Zhou, Yu, Abler and Chen (2014) show income elasticity for general meat were 0.53 overall from the 36 studies, and 0.72 for poultry. They also examined urban-rural sectors, where urban income elasticity was 0.56, while rural income elasticity was 0.74. They noted that urban consumers experience a wider variety of food products and have more restaurant options for dining out. Meals eaten away from home are more likely to include meat relative to meals eaten at home.

For both studies—Zhou, Yu, Abler and Chen (2014) and Bingsheng and Yijun (2008), positive income elasticity values implies that poultry demand will rise with income growth. Both studies have rural income elasticities exceeding that of urban areas. Thus, although urban incomes are rising faster than rural incomes, rural households have larger income elasticity. Therefore, even with a slower income rise, rural areas may see large increases in poultry consumption.

Additionally, the income gap between China's urban and rural residents is widening. The income growth rate of China's urban residents is much higher than that of their rural counterparts. In 1990, China's rural residential income was about 65 percent of their urban counterparts; while in 2012 this ratio dropped to 41 percent (Figure 3). This income gap transfers to Chinese poultry consumption directly.

Comparing Tables 1 and 2 reveals that China's urban population consumes nearly double the poultry meat than its rural population. And it is this urban sector, whose incomes are rising at a faster rate. With positive income elasticity, this again indicates a potential growth market for U.S. poultry exports.

Changing Chinese Diets

Changing Chinese diets also play an important role in increased poultry demand. As income grows, Chinese consumers demand more meat, including poultry. However, other factors also affect the increase in Chinese poultry consumption including the emergence of fast food and quick service restaurants (Pi et al. 2014).

Although Western-style fast food in China is a relatively recent phenomenon, dating back to October 1987 when Kentucky Fried Chicken (KFC) opened its first outlet in Beijing, it has greatly changed Chinese eating customs. Since then, KFC has become the most popular fast food restaurant in China with 4,200 KFCs in 850 Chinese cities as of 2013 (Lin and Patton 2013). In fast food restaurants, poultry is the most common meat ordered mainly due to the poultry meat characteristics: relatively low price; ease of cooking and good taste. And Chinese fast food restaurants have historically obtained poultry meat domestically, within China. The emergence of fast food restaurants in China strongly contributes to China's increased demand for poultry (Pi et al. 2014).

In regards to health issues and food safety outbreaks, Chinese consumers have placed a higher priority on these issues in recent years. From a health point of view, chicken meat has many advantages. Compared with most cuts of red meat, chicken has much less saturated fat and more omega-3 fatty acids (FAO 2013). Chicken meat is considered a healthier meat, which may also increase consumption of poultry meat in China. Food safety outbreaks will be discussed subsequently in the constraints of the Chinese poultry production section.

Demographic Changes and Increasing Urbanization

In addition to rising incomes, population growth has been one of the primary forces driving rising demand for poultry products in China. China's total population increased from less than 1 billion in 1980 to more than 1.3 billion in 2013 (Figure 4). Although China's population growth may slow (World Bank 2014), the impact of urbanization is the next major driving factor for Chinese poultry consumption.

The size of China's urban population has risen much faster than that of its total population (Figure 4). Urban population (including rural migrant workers) has more than doubled over the past two decades. This growth trend is expected to continue, and the urban share forecast to reach 77.3 percent by 2050 (World Bank 2014).

This rapid urbanization has direct implications for poultry consumption–more demand for meat including poultry products. As discussed above, urban Chinese consume more meat than do rural Chinese. The difference in meat consumption between rural and urban Chinese can be seen from Tables 1 and 2 above, as well as documented in Zhou, Yu, Abler and Chen (2014), where both use data sources from the National Bureau of Statistics of China.

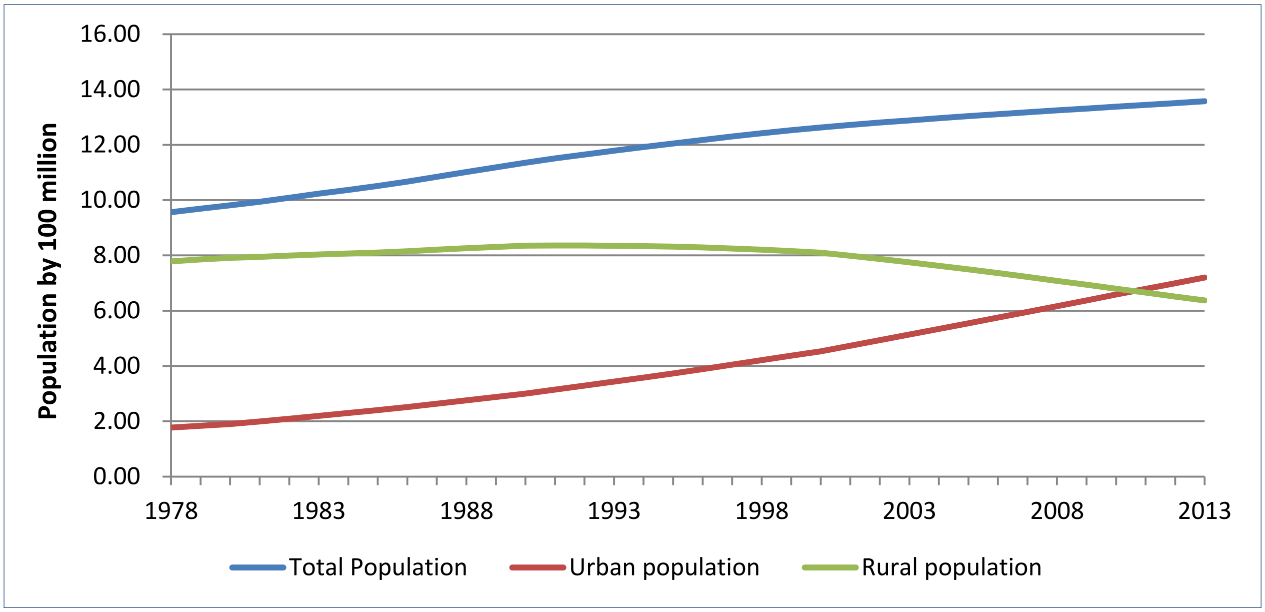

Figure 4. Population Growth in China
Source. National Bureau of Statistics of China, China Statistical Yearbook 2013.

Combining the three major driving factors for Chinese poultry consumption (urban growth, rising incomes and changing diets), it appears that the Chinese poultry consumption growth rate will maintain a high level in the future and, therefore, may provide opportunities for U.S. poultry exporters. That is, if these factors continue to change as in the past—which they may not. Additionally, as Chinese incomes rise, income elasticities may decline.

China's Evolving Market-Supply Side

China's poultry industry experienced rapid growth from 28 million tons in 1989 to 160 million tons in 2009, due to an increase in China's own poultry industry (Figure 5). Pork and poultry are China's primary livestock products produced domestically. Figure 6 shows the relative share of each product and the growth of poultry, from less than 10 percent of total livestock production in 1984 to over 20 percent in 2009.

China's poultry industry has undergone rapid structural change from a large number of small-scale farmers—smallholders—to large-scale industrialization with horizontal and vertical integration (Bingsheng and Yijun 2008; Pi, Zhang and Horowitz 2014). As recent as two decades ago, China's poultry sector consisted of hundreds of millions of smallholders, each with a limited number of chickens or ducks. No large-scale commercial poultry farms existed, with the exception of a few state farms located near cities (Bingsheng and Yijun 2008).

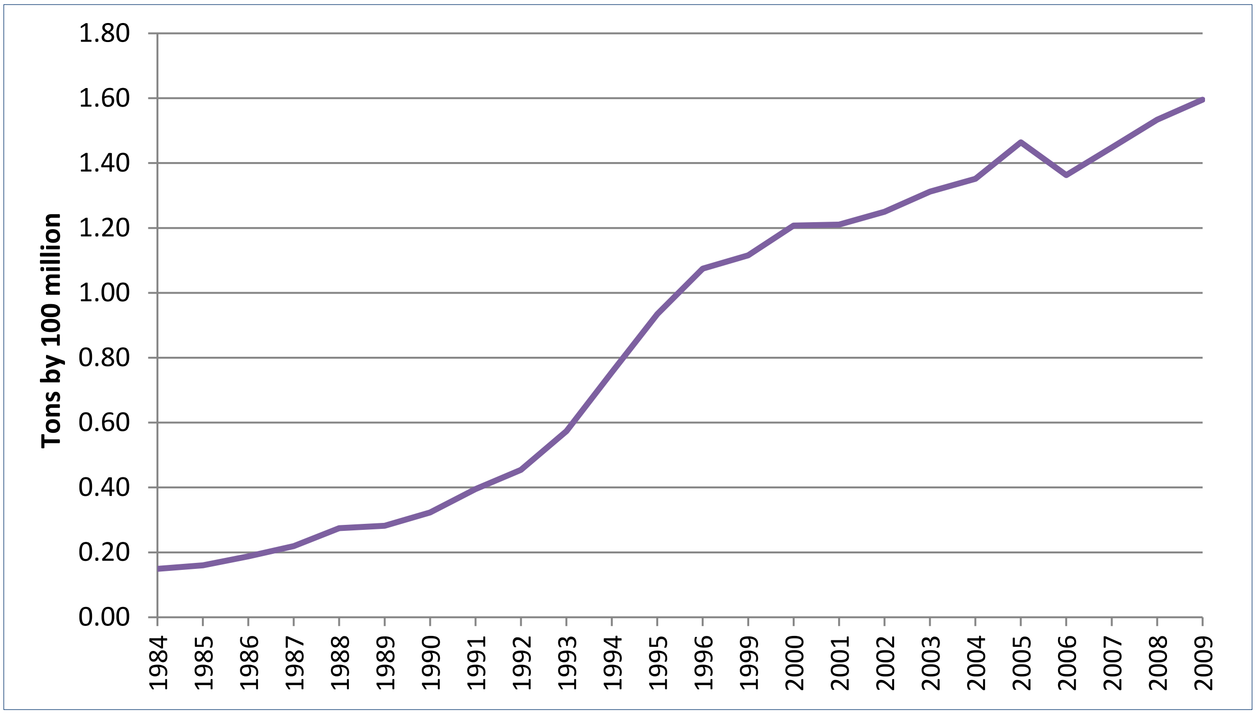

Figure 5. China's Total Poultry Production (100 Million tons)
Source. USDA-ERS China Section 2014.

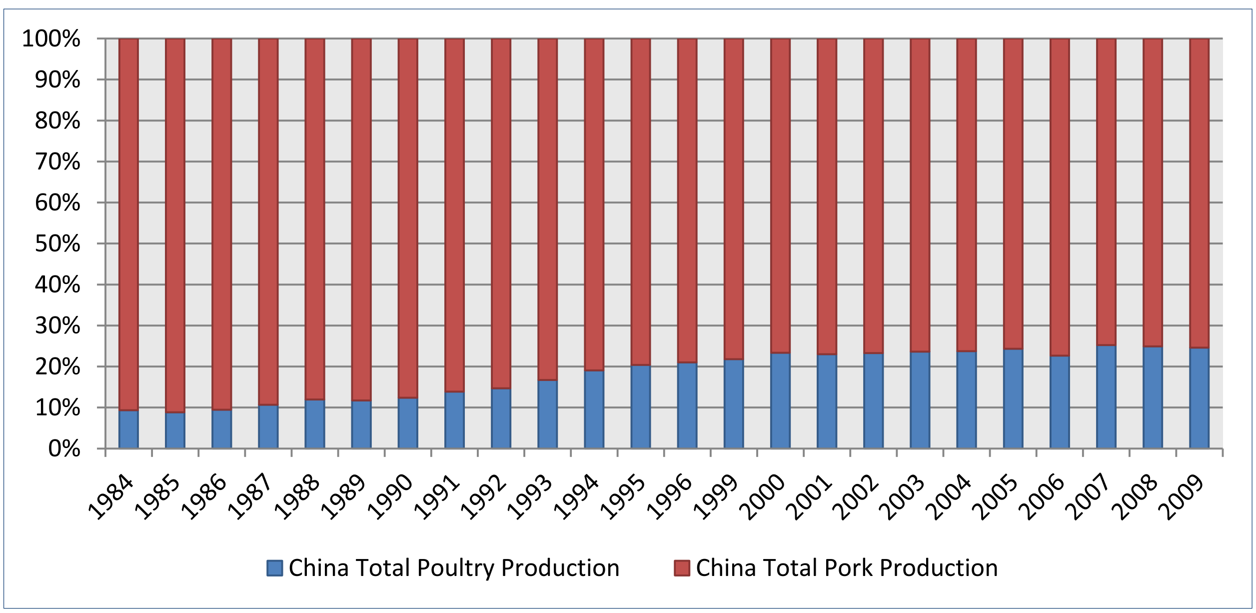

Figure 6. Poultry's Relative Share of Livestock Production in China—Poultry vs. Pork
Source. USDA-ERS China Section 2014.

According to Pi et al., between 1985 and 2005, 70 million small poultry farmers left the sector and within a period of fifteen years (1996–2011), the total number of broiler farms in China decreased by 75 percent. China's small farmers (less than 2,000 birds) totaled 62% of total poultry farms in 1998 and 30% in 2009. Between 2007 and 2009, the number of China's small farmers declined by two million to 26,609,204 farms, even though they continue to be the dominant type of poultry farm. Concurrently, the number of broiler farms producing more than one million birds annually rose by nearly 60 percent from 128 to 202 farms (Pi, Zhang and Horowitz 2014). Part of this structural change is due to food safety concerns as discussed below.

China is now the second largest producer of poultry products, behind the United States (Pi et al. 2014). The main production areas are in the eastern and central regions of China, with the east dominant and near high-income consumers on China's East coast. Technological and managerial improvements are the main drivers for China's poultry supply increase. "Of all the factors affecting the input side of poultry production, technology is by far the most important. New breeds with higher productivity, new feeding systems, new raising facilities and new methods of poultry production management have all contributed to the improvement of poultry production efficiency, and have pushed the sector towards intensification." (Bingsheng and Yijun 2008).

Pi, Zhang and Horowitz (2014) describe four stages of production growth: slow growth from 1961 to 1978, fast growth from 1979 to 1996; standardization and scaling-up from 1997 to 2009; and restructuring and upgrading since 2010. The "grow out" model of production is increasing in an effort to counter food safety problems, control the supply chain and increase traceability—where a company owns and manages the supply chain from feed production, breeding, hatching, fattening, slaughter and processing, and is even more integrated than U.S. contract poultry farming.

Constraints of Chinese Poultry Production

Although China is experiencing rapid growth in poultry production, constraints remain for China's poultry sector development. Constraints include high feed costs (Figure 7), particularly maize and soybeans. Environmental regulations that promote sustainable economic development may increase feed costs. Avian influenza and other diseases may have a major effect on the development of poultry sector in China. Food safety issues in China may lead Chinese consumers to switch to imported food. These constraints will be discussed below.

High Feed Costs

One of the most potentially unfavorable factors for the future development of the poultry sector in China is the supply and price of feed, in particular for maize and soybeans (Gale, Hansen and Jewison 2015). As shown in Figures 7 and 8, maize production in China has steadily grown in the past decade, and reached a historic record of 177.25 million tons in 2010 (almost a 60 percent increase since 1995). However, China's production of soybeans in 2009 is almost the same as it was 25 years ago, far from the amount needed today as witnessed via large volumes of soybean imports, with the U.S. being a major supplier to China.

About two-thirds of China's maize production growth was achieved by expansion of the cropping area and one-third by yield improvement (Bingsheng and Yijun 2008). However, the potential to further expand China's maize cropping area is limited due to China's arable land constraint. China is feeding more than 22 percent of the world's population on less than seven percent of the arable land available worldwide. The main hope for increasing production is yield improvement, which takes time.

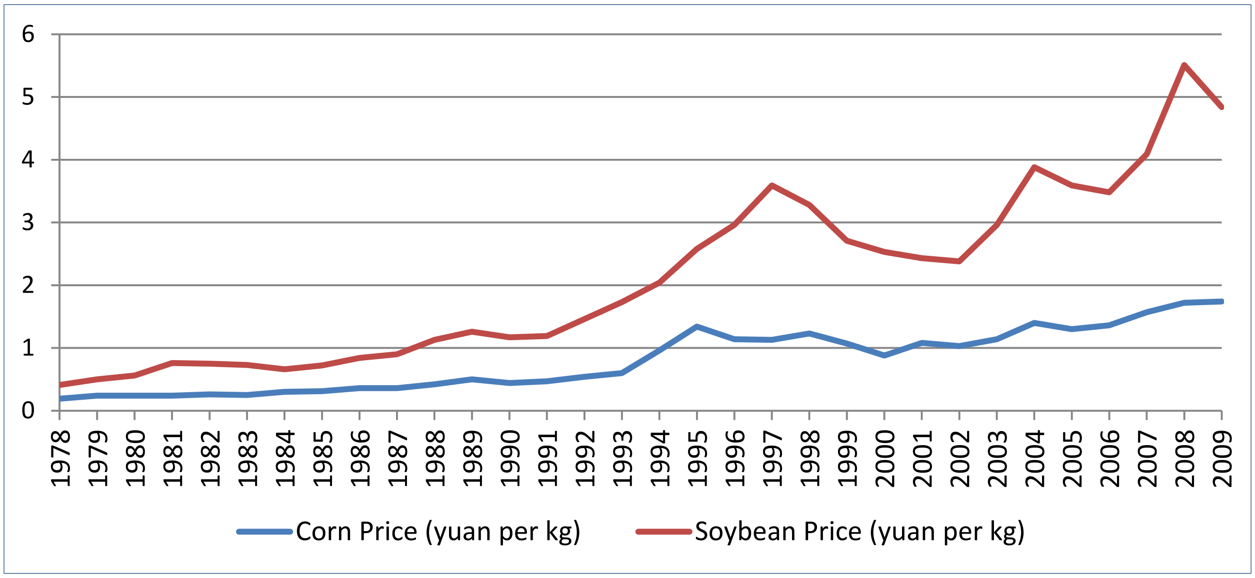

Figure 7. China's Maize and Soybean Prices
Source. USDA-ERS China Section, 2014.

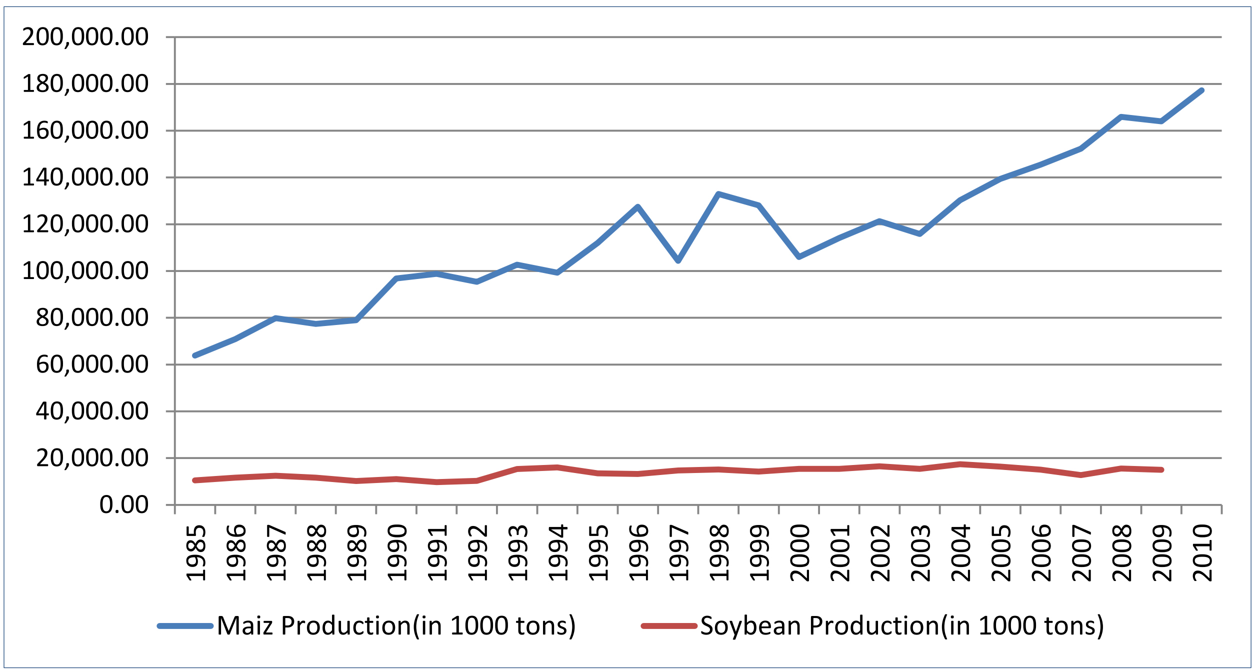

Figure 8. China's maize and soybean production
Source. USDA-ERS China Section, 2014.

Food Safety—Avian Influenza

Another limiting factor in China's poultry production is disease. China's first outbreak of the Avian Flu (AF) occurred in China in 1996 when the highly infectious H5N1 was found in Guangdong Province (Pi, Zhang and Horowitz 2014). This occurred concurrently with China's growing poultry sector. Since then, AF has been reported in 60 countries. In China, AF has been reported every year except 2011. In 2013, Avian Flu (H7N9) was reported in China's major cities including Beijing and Shanghai, and resulted in 44 human deaths and 135 infections. China's poultry industry's economic loss was estimated at RMB 60 billion ($9.68 billion) (USDA 2013, GAIN Report). Much of the blame was on China's wet markets—open-air stalls where many Chinese consumers have traditionally shopped for fresh meat and produce, including live birds—as well as China's poultry smallholders (Pi et al. 2014; Peng, Marchant, Qin and Zhuang 2005) for a discussion on China's evolving retail food markets from wet markets to super/hyper markets).

Most recently, AF affected several southern major poultry producing provinces, such as Guangdong, Zhejiang, Jiangsu, and Fujian. Since the beginning of 2014, China's poultry industry experienced losses of at least RMB40 billion ($6.5 billion), compared to the 2013 losses of RMB60 billion ($9.8 billion); Guangzhou's largest poultry wholesale market announced that in January, 2014 it lost RMB10 million ($1.6 million) (USDA- GAIN Report 2014a).

"For the first time in nearly 40 years, this market's live bird sales (per day) dropped from 60,000 to 30,000 birds. Hangzhou, the capital city of Zhejiang Province, closed its major live bird markets on February 15, 2014. Other major cities in Zhejiang Province will follow suit starting in July 2014. The reopening dates for Zhejiang's live bird markets have not yet been determined. In place of live-bird markets, sources note that processors are now providing more fresh/chilled broiler carcasses to local supermarkets and specialty shops….Given ongoing H7N9 virus detections, sources note that China's 2014 broiler meat consumption will likely fall by six percent to 12.7 million tons" (USDA-GAIN Report 2014a).

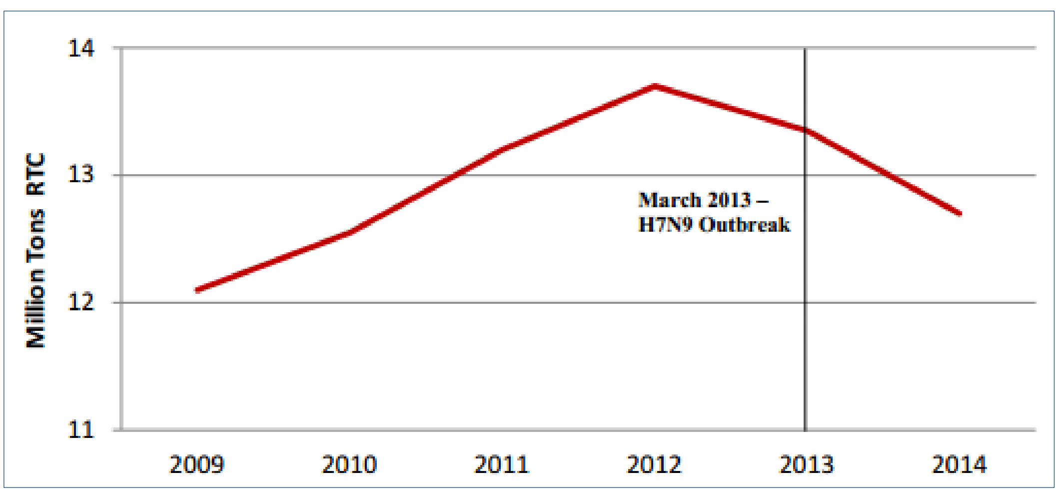

Figure 9. China's 2013 Avian Influenza outbreak
Source. USDA-FAS Livestock and Poultry 2014b.

Food Safety—Processing

In addition to Avian Flu, in 2012 China experienced the KFC "Instant Chicken" scandal (Pi, Zhang and Horowitz 2014). A Chinese TV station reported that small holders who were KFC suppliers were feeding chickens antiviral drugs and hormones to speed growth. Both AF and this scandal resulted in decreased profits and increased public attention to food safety. As a result in 2013 KFC cut contracts with 1000 small holders to "enhance quality control" and support the "grow out" production model.

In December 2013, a USDA audit of poultry meat from China found that China's poultry slaughter system was not yet equivalent to that of the United States in terms of food safety. "PRC will have to make changes to ensure that every carcass receives adequate inspection" (USDA 2013).

Meanwhile in China, a website called "Throw it Out the Window" (www.zccw.info), tallying China's food safety outbreaks since 2004 (reporting 3,449) is getting more attention from Chinese consumers. A recent news story highlighted a Chinese food processing scandal. On July 27, 2014, the Chinese government suspended operations at Shanghai Husi, a subsidiary of OSI Group LLC, that supplies meat to many global brands operating in China. It was accused of repackaging old beef and chicken with new expiration dates.

Shanghai Husi's main cooperators included McDonalds, Yum! Brands (KFC, Pizza Hut and Taco Bell) and Starbucks. As the Chinese government investigated Husi, some McDonalds' restaurants did not have beef or chicken. Yum! Brands also warned that the bad publicity has "shaken consumer confidence" and resulted in a "significant, negative impact" at its KFC and Pizza Hut chains in China. "Yum said KFC sales in China plunged 37 percent the following month" (McDonald 2014). One month later, McDonalds China, Burger King, KFC and 7-Eleven officially terminated its partnership with Husi and obtained new Chinese suppliers. OSI spent over two decades and US$750 million to build its business in China, which collapsed after the expired meat scandal.

The above food safety examples resulted in decreased profit and increased public attention to food safety issues. In response, China sought to improve food safety through investment, greater control of the supply chain through vertical integration, encouragement in changing Chinese consumers' preferences from fresh poultry sold in wet markets to chilled/frozen poultry sold in a super/hypermarkets (Pi et al. 2014). These constraints, high feed costs, and food safety issues, provide the U.S. an opportunity to export its low priced, high-quality poultry products to China.

U.S. Poultry Exports to China

Overview

U.S. firms began exporting poultry to China beginning in the 1990s. The U.S. was the largest supplier of poultry exports to China consisting mostly of less valuable poultry cuts such as chicken paws (feet), frozen chicken cuts, and offal (internal organs), viewed as complimentary by-products of chicken breasts for the U.S. domestic market (Zhang and Gunter 2004; Zhang 1996). U.S. broiler parts accounted for 60 percent of China's total poultry imports. Han and Hertel (2003) discussed interesting aspects of analyzing trade data with China including which areas to include, e.g., Hong Kong for transshipment; which units to use given that China imports low-value by-products such as chicken feet yet exports high-value processed products such as skewered meat; and which type of meat products to include. For this analysis, we rely on the Foreign Agricultural Service's Production, Supply, and Distribution database (USDA 2014) and the Economic Research Service's (USDA 2012) China section databases.

The 2015 publication China's Growing Demand for Agricultural Imports by Gale, Hansen and Jewison provides an excellent overview of U.S.-China trade patterns and summarizes alternative projections for future agricultural imports from the U.S. to China. Key points include

- the existence of a "strong agricultural trading partnership" that will likely continue, while acknowledging that "Chinese interventions to preserve self-reliance create volatility and uncertainty that can disrupt markets" (Gale, Hansen and Jewison, 2015)
- with China joining the World Trade Organization (WTO) in 2001 came lowered trade barriers and increased trade opportunities
- imports of meat and dairy products surged as China faced increased costs for feed and forage and
- projections by USDA and other sources anticipate continued growth in Chinese agricultural imports through 2023, with soybeans being China's dominant agricultural import, and imports of corn and meat expected to rise as well.

By looking at the trend of U.S. poultry exports to China (Figure 10), key declines occurred in 2004 and 2009. U.S. poultry exports to China decreased significantly. These two years represent two important scenarios due to food safety and trade policy issues respectively—U.S. avian flu outbreaks (2004) and China's imposition of antidumping and countervailing measures (2009). In this section, we will explain how the two scenarios happened.

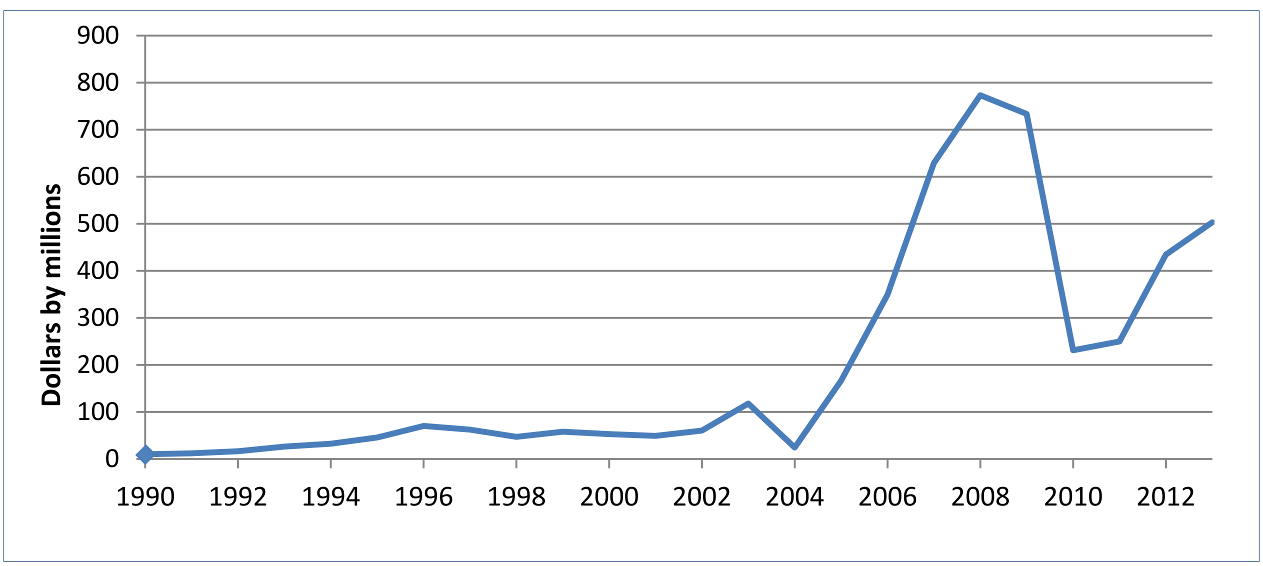

Figure 10. U.S. Poultry Export to China
Source. USDA-ERS China Section, 2014

Exports to China

In the first 15 years of U.S. poultry exports, beginning in 1990, China was not a very important market to the U.S. poultry industry (Figure 11). However since 2005, due to China's increasing domestic demand, open market policies and favorable U.S. prices (especially chicken feet), U.S. poultry exports to China began expanding.

Chicken feet, nicked-named "phoenix talons," is one of the major U.S. export poultry types to China. Until the mid-2000s, chicken feet were considered a castaway item and removed at U.S. processing plants even before reaching USDA inspection stations. As reported by Time Magazine (2010), "In 2008 the U.S. exported $677 million worth of chicken to China, according to the USDA, a fraction of the total $36 billion U.S. poultry market. Roughly half of those exports were chicken feet, worth $0.60 to $0.80 per pound on the Chinese market but just pennies in the U.S." Thus, providing a market for chicken parts that most U.S. consumers would not eat can be profitable.

However, this U.S. leading market share for Chinese poultry imports was eroded by South American competitors, especially Brazil, mainly due to China's restrictive trade policy and food safety issues toward the United States as discussed in the food safety section below. For example, for the first half of 2013, USDA reported that the U.S. poultry export price to China was $1,729 per ton, 44 percent cheaper than its South American competitors (USDA-GAIN Report 2014). Despite this favorable price, U.S. exports were impacted by China's decision to reinstate a ban on Arkansas poultry and impose restrictions on Wisconsin poultry, due to low pathogenic detections in poultry from both states (USDA-GAIN Report 2013).

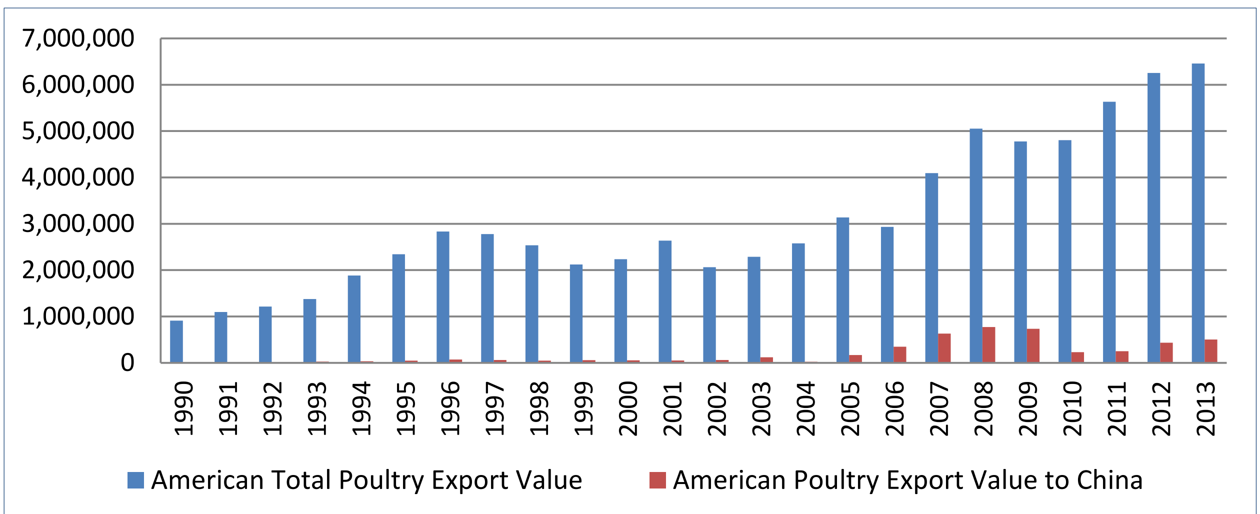

Figure 11. Poultry Exports to the World and China (in thousands of dollars)
Source. USDA Production, Supply, and Distribution database, 2014

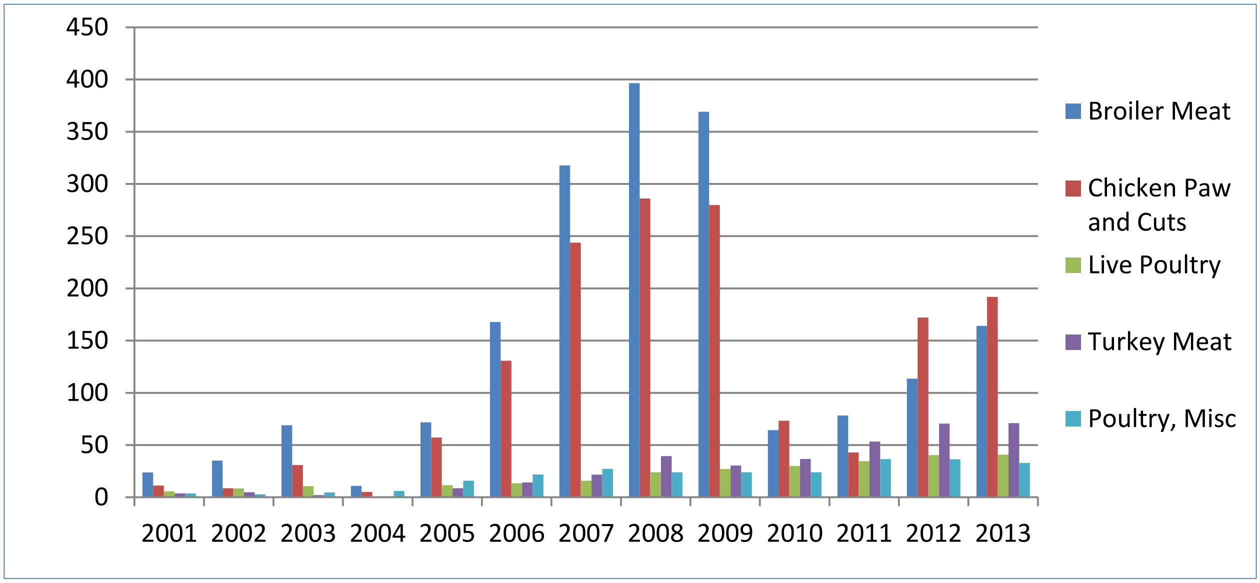

Figure 12. U.S. Poultry Exports to China by Type (in one million dollars)
Source. USDA Production, Supply, and Distribution database, 2014

U.S. Trade Barriers: Food Safety

On February 6, 2004, avian flu (virus subtype H7) was discovered at a farm in Delaware, where 12,000 chickens were culled, suspected to be infected. In accordance with the "Law of the People's Republic of China on the Entry and Exit Animal and Plant Quarantine," to prevent transmission of the disease into China, protect the safety of husbandry industry and public health, the Chinese government suspended U.S. poultry imports (USDA-FAS, GAIN Report 2004a).

Following the above ban on poultry imports, on November 8, 2004 China lifted its import ban on U.S. live poultry and poultry products (USDA-FAS, GAIN Report 2004b). U.S. poultry products from all states, except Connecticut and Rhode Island, processed on or after November 9, 2004 were now permitted entry into China. Due to the ban, U.S. poultry exports to China experienced a dramatic fall in 2004, which increased thereafter (Figure 10).

Since then, China has imposed and lifted numerous import bans on poultry from selected states. For example, on May 15, 2013, China lifted its ban on Arkansas poultry that had been imposed since June 2008 due to an outbreak of H7N3 low pathogenic bird flu virus in Arkansas. A mere two months later, on July 22, 2013 China's Ministry of Agriculture (MOA) reinstated the ban on Arkansas poultry due to a H7N7 bird flu outbreak. China also banned Wisconsin poultry due to H5N2-B bird flu outbreak. Most recently, in May 2014, China lifted its seven-year ban on Virginia's poultry exports stemming from avian flu. Gov. Terry McAuliffe announced China's decision to lift the ban, saying that it could boost the state's poultry exports by $20 million or more a year (Virginia.gov 2014). Unfortunately as of this writing (July 14, 2015), China re-instituted its ban on U.S. poultry imports (Polansek 2015).

From the above cases, a food safety ban can be a crucial issue in the future of U.S. poultry exports to China requiring an understanding of Chinese food safety regulations and communicating effectively to minimize unwarranted food safety bans in the future.

U.S. Trade Barriers: Trade Distorting Policy

Poultry was one of China's top four agricultural imports from the U.S. 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 in 2005 to 80 percent in 2009, gradually edging out poultry imports from Argentina and Brazil (U.S. International Trade Commission 2011).

However in 2010, the U.S.'s market share of China's imports fell significantly— down 80 percent from 2009 due to trade distorting policies (USDA-GAIN Report 2013). In 2009, Beijing accused Washington of "rampant protectionism" for imposing heavy duties on imported Chinese tires and threatened action against imports of U.S. poultry and vehicles (Dyer and Braithwaite 2009). On September 27, 2009, China's Ministry of Commerce (MOFCOM) initiated antidumping and countervailing investigations of imports of so-called "broiler products" from the United States. Broiler products include most chicken products, with the exception of live chickens and a few other chicken products such as cooked and canned chicken.
China's MOFCOM imposed antidumping and countervailing duties on these products on September 26, 2010 and August 30, 2010, respectively. The antidumping duties ranged from 50.3 percent to 53.4 percent for the U.S. producers who responded to MOFCOM's investigation notice, while MOFCOM set an "all others" rate of 105.4 percent. In the countervailing duties (CVD) investigation, China's MOFCOM imposed countervailing duties ranging between 4.0 and 12.5 percent for the participating U.S. producers and an "all others" rate of 30.3 percent.

On September 20, 2011, the U.S. requested dispute settlement consultations with China concerning the conduct and results of MOFCOM's antidumping and countervailing duty investigations. After consultations proved unsuccessful, the U.S. requested that the WTO establish a panel to hear U.S. claims that China violated numerous procedural and substantive obligations under the WTO's Antidumping Agreement and Agreement on Subsidies and Countervailing Measures (Office of the U.S. Trade Representative 2013).

On August 2, 2013, the WTO issued the panel report in the dispute "China — Anti-dumping and countervailing duty measures on broiler products from the United States." The WTO panel agreed with the U.S., finding that China violated numerous WTO obligations in conducting its investigations and imposing antidumping duties and countervailing duties on chicken imports from the United States.

On December 25, 2013, the Chinese Ministry of Commerce announced its reinvestigation of China's anti-dumping/countervailing measures against U.S. broiler meat products, based on the WTO ruling on the case. Most recently on July 8, 2014, China lowered its anti-antidumping and anti-subsidy duties. New anti-dumping levies range from 47 to 74 percent, down from 105 percent. Now anti-subsidy levies are 4 percent, down from 30 percent (Reuters 2014). These duties impacted China's imports of U.S. poultry exports as seen in the dramatic decrease in U.S.

exports starting in 2009 (Figure 10). With the recent reduction in levies, this further provides opportunities for U.S. poultry exporters.

Future Forecasts—USDA and Rabobank

In regards to the future, USDA forecasts that China's 2014 broiler imports from the U.S. will reach 270,000 tons, a four percent increase from its updated 2013 estimates (USDA 2013, GAIN Report). And in 2014, import estimates are expected to be the highest over the past four years. However, this is far below the record high import level of 480,000 tons in 2007, before China imposed its antidumping duties and countervailing duties on U.S. poultry and poultry products.

USDA's 2015 projections through 2023, along with those from other sources--OECD/FAO, China's Academy of Agricultural Sciences (CAAS) and China's Research Center for Rural Economy (RCRE)--all predict continued growth of varying magnitude in China's imports of corn, soybeans and meat (Gale, Hansen and Jewison 2015).

And for Rabobank, as cited by Pi, Rou and Horowitz (2014), "Despite a declining overall trend in imports in recent years, Rabobank (2013) believes that China's poultry imports will increase because of China's complementary market for offal compared to the rest of the world." Rabobank (2013) states that although poultry "has been, in many cases, in the shadow of pork"…it "will likely develop its own growth path, which will be independent from the pork market. China's poultry market has more growth potential than pork or beef or mutton…"

Conclusions

From China's poultry demand side, domestic poultry consumption growth is clear. Three main reasons (rising incomes, changing diets and increasing urbanization) explain this dramatic growth. As incomes rise, Chinese consumers consume more meat overall with poultry consumption increasing fastest among meats. For increased urbanization, per capita poultry consumption is higher than rural consumption, tripled over the past two decades (Tables 1 and 2) and also experienced the rise of fast food in urban areas. With continued increases in these same demand determinants, China's domestic poultry consumption is expected to continue to grow in the future.

On the supply side, China can still produce enough poultry products in the short term to meet Chinese consumers' demand. However, from a long-term perspective, China's domestic supply may not keep pace with the rapid growth of China's domestic demand due to supply constraints--high feed costs, limited arable land to grow feed, and food safety issues via Avian Flu on the production side and food safety outbreaks in poultry processing plants. As discussed in the Food Safety section, China continues to face food safety issues and seeks to solve these issues through rapid structural change via removing small holder poultry producers, vertical integration to control the supply chain using a "grow out" production model, and in changing Chinese consumers' preferences from fresh poultry sold in wet markets to chilled/frozen poultry sold in super/hypermarkets.

U.S., poultry exports to China increased over time, only to drop significantly in 2004 and 2010 due to China's imposition of import bans. Starting in 2004, U.S. avian flu outbreaks on individual U.S. farms led to import poultry bans for entire states, e.g., Virginia. And in 2009, China imposed antidumping and countervailing measures on poultry imports from the U.S., later ruled in violation of WTO rules, resulting in the most recent lowered duties on Chinese imports. This new action provides an opportunity for U.S. poultry exporters.

Although China is not one of the top U.S. poultry export destinations (Figure 11), it is still a very important potential market to the U.S. especially for complementary products—chicken feet and offal. China may not have the rapid expansion of U.S. poultry exports in the short term because it can currently produce enough for its own consumers. However, in the long run, China's poultry sector may be limited more from its constraints. This provides the U.S. poultry industry with an opportunity to benefit from the potential world's largest poultry market. In order to promote U.S. poultry exports to China, it is essential to maintain a positive dialog and understanding between the two countries for the benefit of each.

Acknowledgements

Acknowledgements: Funding for this work was provided in part, by the Virginia Agricultural Experiment Station and the Hatch Program of the National Institute of Food and Agriculture, U.S. Department of Agriculture (USDA-NIFA) and the Agriculture and Food Research Initiative (AFRI), USDA-NIFA-AFRI Grant Number 2014-67023-21946, "Expanding U.S. Market Access in China's Evolving Agricultural and Trade Policy Environment." Additionally, the authors are grateful for the information provided by Dr. James Hansen of the USDA-Economic Research Service and helpful comments by Editors Christopher Davis, Peter Goldsmith, Technical Editor Kathryn White and two anonymous reviewers.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

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.

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

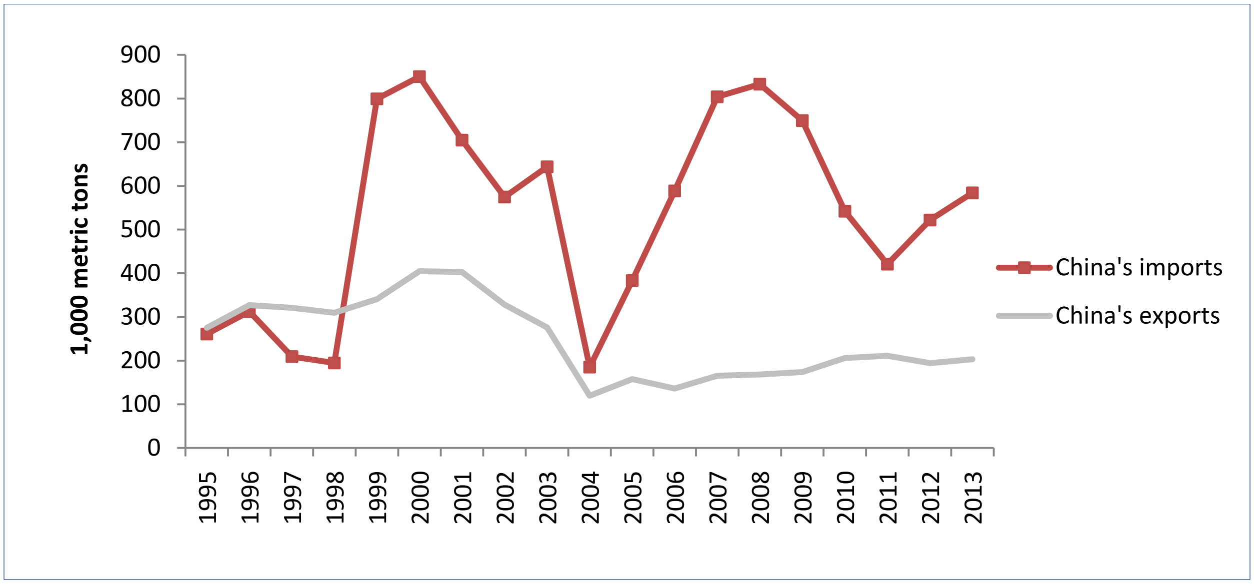

Figure 1. China's Trade in Poultry Meat 1995-2013

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.

[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).

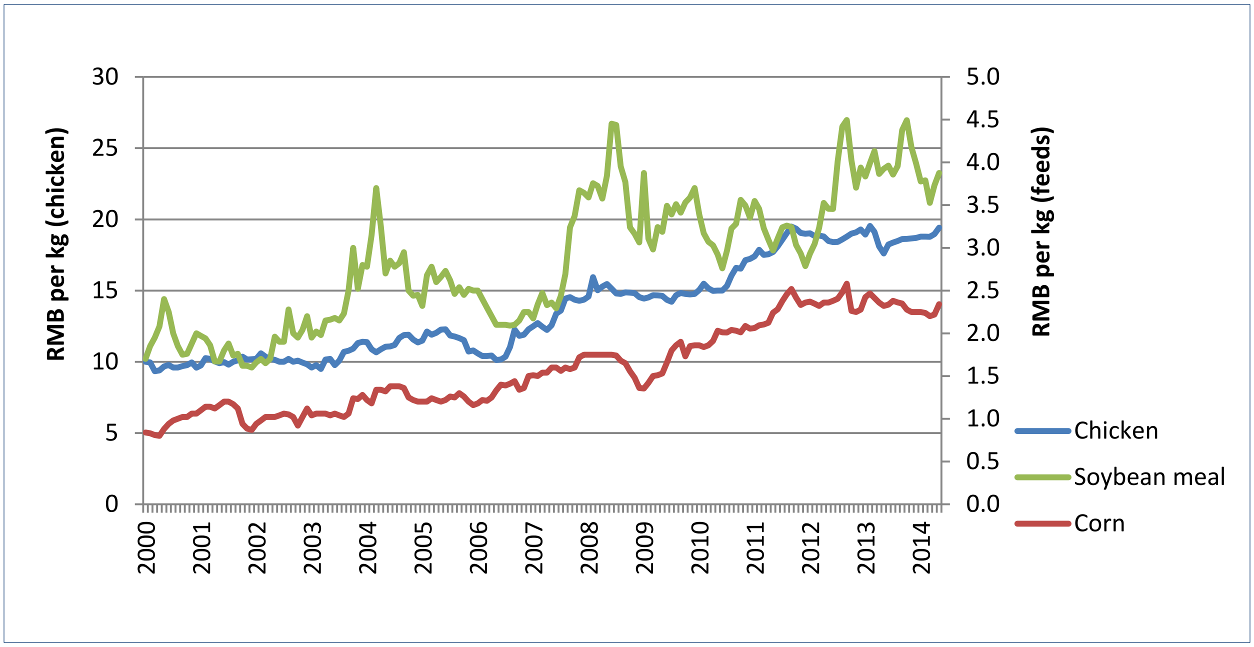

Figure 2. China Chicken and Feed Ingredients Prices 2000-2014

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.

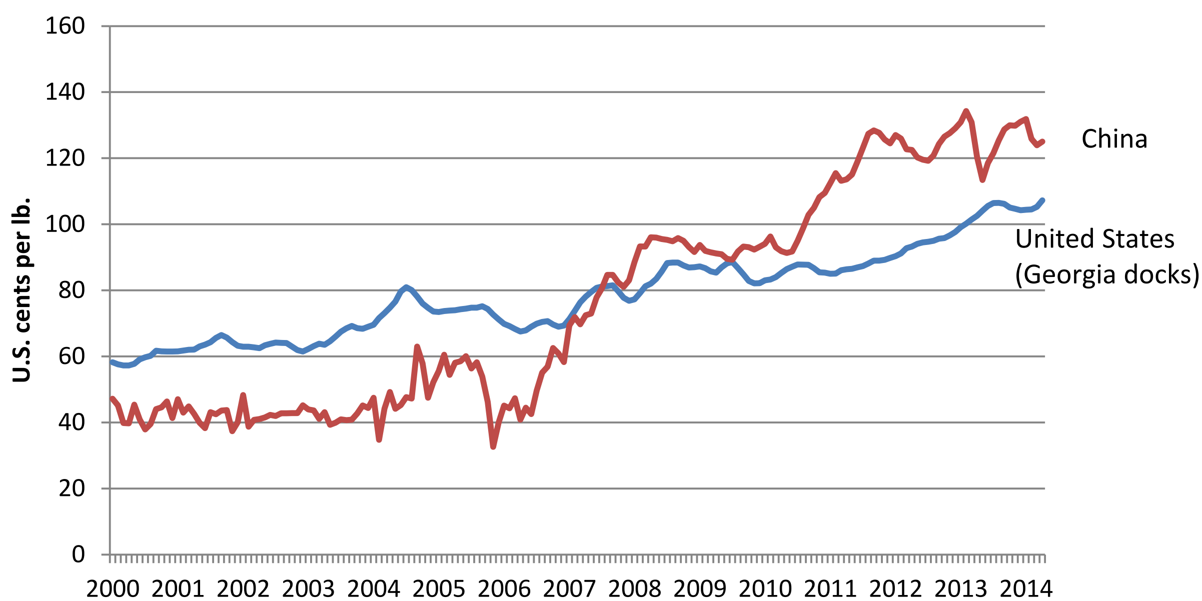

Figure 3. Wholesale Chicken Prices, China and U.S. 2000-2014

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).

Acknowledgements

The authors thank China National Grain and Oils Information Center for providing price data.

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Appendix

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

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

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.

International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

India's Poultry Revolution: Implications for its Sustenance and the Global Poultry Trade

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Abstract

As one of largest emerging economies, the Indian poultry market has wide-ranging implications for global poultry production and trade due to its sheer size, national market and rapid structural growth. Availability of low-priced, high-quality feeds is critical in order for domestic poultry production to remain competitive and meet growing consumer demand. Production of maize, which is a predominant feed component in poultry industry, has surged in India. With average Indian maize yields lagging world and Asian averages, there are significant maize intensification opportunities to produce even more and cheaper feed, including increased use of higher-yielding (and higher-quality) maize hybrids and associated private- and public-sector investments. Given the size of the India's poultry sector, its price competiveness and Indian entrepreneurship, India is set to take a more active role in the global poultry trade especially with respect to exports to the Middle East.

Keywords: India, poultry industry, global poultry trade, maize, animal feed

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Introduction

In response to rising incomes and changing consumer preferences, significant market opportunities for high-value agricultural products such as meat have emerged in developing countries. Since 1960, global meat production has multiplied more than three times, and egg production nearly four times (Speedy 2003). The global demand for meat is predicted to rise by more than 55% between 1997 and 2020, with meat production reaching 455 million tons by 2050 (Alexandratos and Bruinsma 2012). Demand for poultry – primarily chicken which constitutes more than 90% of market value – is fuelled by similar economic factors (Ravindran 2013). The production of poultry meat worldwide increased from 9 million tons in 1960 to 105 million tons in 2012 (Speedy 2003; FAOSTAT 2012). On the supply side, several factors have contributed to the worldwide growth in poultry production: (i) genetic progress in poultry strains for meat and egg production; (ii) better understanding of nutrition fundamentals; and (iii) disease control (Ravindran 2013).

Most of the increase in poultry production is taking place in developing countries, especially in Asia. This region now accounts for more than a quarter of current global poultry production. India is one of the largest poultry producing countries in Asia. From being largely a backyard venture before the 1960s, the Indian poultry sector has evolved into a vibrant agribusiness spurred by domestic economic growth and consumption dynamics. The share of poultry in domestic meat production has grown from 23% in 2004-05 to 51% in 2009-10 in the country. Poultry is low-cost for consumers, relative to other meat products, and has comparatively wider acceptability across regions and religions (Manning and Baines 2004). This is particularly important in India where the predominant Hindu religion largely limits beef consumption and Islam, that of pork. On the other hand, the share of the population that does not eat any meat because of religious beliefs, as opposed to an economic necessity, is small, as low as 10-20% (Landes et al. 2004). Furthermore, the growing middle class is more likely to disregard traditional taboos and religious bias against non-vegetarianism (Rattanani 2006).

The increased availability and affordability of poultry meat and eggs for both rural and urban poor is contributing to improved nutrition and poverty reduction (Pica-Ciamarra and Otte 2010). The poultry industry in India also offers domestic employment opportunities. Furthermore, as one of largest emerging economies, the Indian poultry market has wide-ranging implications for global poultry production and trade – both in terms of the sheer size of its national market and its rapid structural growth. Availability of low-priced, high-quality feeds–a major ingredient of which is domestically-produced maize was and remains critical for domestic poultry production to remain competitive and meet surging consumer demand. This has limited the prospects for traditional poultry exporters such as the United States and Brazil to break into the Indian market. Furthermore, India is expanding its poultry exports to regions such as the Middle East, further threatening the export markets of traditional suppliers of poultry products.

Based on an extensive literature review of secondary literature, this paper reviews the Indian poultry revolution: (i) describing the exceptional growth of India's poultry industry, the structural developments and the underlying reasons; (ii) assessing its implications for the global poultry trade; and (iii) assessing the implications to sustain it, particularly in terms of feed market development and the environment.

Growth of the Indian Poultry Industry

Vertically-Integrated Poultry Production

Economic growth in India and the subsequent increased in incomes has led to a greater demand for high value products such as poultry meat and eggs. To ensure quality and consistent supply of perishable inputs and outputs, the poultry industry in India has rapidly evolved toward more vertical coordination, allowing retailers to standardize quality, improve bargaining power, and achieve economies of scale. Currently, there are about 60 thousand poultry farms in India under modern intensive systems of management. While there is still some backyard poultry farming, it is relatively unorganized, economically less significant and small-scale (Conroy et al. 2005). Growth in the poultry sector has been engineered and dominated by the large-scale commercial private sector, which controls roughly 80% of total Indian poultry production (Joshi et al. 2003) and is concentrated in the southern states of Andhra Pradesh and Karnataka (Krishna et al. 2014).

India is the third largest egg producer and fifth largest poultry-meat producer in the world (Mitra and Bose 2005). By 2003, India was producing 1.6 million tons of poultry-meat, which had risen to 2.0 million tons by 2006 (Hellin and Erenstein 2009), and now stands at 2.2 million tons per annum (www.dahd.nic.in). Poultry meat production in India is second only to China in Asia at present, whereas the annual growth rate over 2003-12 is third after South Asian neighbors Nepal and Pakistan (Table 1). By 2030, it is expected to reach about 3.0 million tons per annum (Joshi and Kumar 2012). The per capita consumption of meat is expected to increase in India, from its current level of 3.1 kg to up to 18 kg by 2050, of which 12.5 kg would be chicken (Alexandratos and Bruinsma 2012). Recent attempts to ban calf slaughter and beef products by some state governments of India (Rashid, 2015) could further increase the demand and consumption for poultry products in the country.

Table 1. Poultry Meat Production in Asia

Country	Annual average production (million MT) 2011-13	Production CAGR (%) 2004-2013	Average per capita supply (kg/ year) 2009-2011	Per capita supply CAGR (%) 2002-2011
Bangladesh	0.21	3.53	1.37	2.72
Cambodia	0.03	0.61	2.07	-1.11
China	17.20	4.39	12.17	2.97
India	**2.24**	**6.80**	**1.83**	**5.62**
Indonesia	1.68	5.09	6.50	3.58
Nepal	0.03	11.67	0.87	9.87
Pakistan	0.77	9.30	4.13	6.97
Philippines	0.94	4.48	10.57	3.18
Thailand	1.33	0.09	12.13	0.37
Vietnam	0.58	3.45	12.43	12.98

Note. MT=Metric Tons, CAGR=Compound Annual Growth Rate
Source. Computed based on FAOSTAT online database

Meanwhile, annual egg production in India increased from 10 billion to 29 billion between 1980/81 and 1998/99 (Ramaswami et al. 2006) and has continued its rapid growth ever since (Table 2). More than 75% of the absolute growth of global egg production between 1990 and 2007 were contributed by China and India (Winhorst 2009).

Egg production in India is likely to surge from the current level of about 66 billion to 95 billion by 2015. Joshi and Kumar (2012) forecast Indian egg supply to reach around 124 billion numbers by 2030. Egg production is again second only to China in Asia at present, whereas the annual growth rate over 2003-12 is just second to Pakistan (Table 2).

Table 2. Egg Production in Asia

Country	Annual average production (million MT) 2010-12	Production growth rate (%) 2003-2012	Average per capita supply (kg/ year) 2009-2011	Per capita supply CAGR (%) 2002-2011
Bangladesh	0.28	2.97	1.40	1.60
Cambodia	0.02	3.88	1.37	1.73
China	28.24	2.37	18.47	1.76
India	**3.49**	**5.39**	**2.37**	**3.91**
Indonesia	1.33	3.57	4.47	1.73
Nepal	0.04	4.11	1.13	2.05
Pakistan	0.59	5.62	2.70	3.25
Philippines	0.48	4.06	4.27	2.31
Thailand	1.01	2.16	11.57	1.86
Vietnam	0.34	4.16	3.23	4.13

Note. MT=Metric Tons, CAGR=Compound Annual Growth Rate
Source. Computed based on FAOSTAT online database.

Availability of Low-Priced and High Quality Animal Feed

The poultry industry in India has benefited from scientific advances in poultry breeding and disease control but an additional factor has been the availability of low-priced, high-quality feed (Ravindran 2013). For broiler production, feed is the largest single production cost (Davis et al. 2013) and can constitute up to 70 percent of the total costs. In the case of poultry production in India, feed accounts for 55-64% of variable costs (Landes et al. 2004). The predominant grain used in poultry feeds is maize (or corn, *Zea mays* L.). Poultry feed normally contains 60-65% of maize. For both broiler and layer rations, maize accounts for most of the energy in the feed ration, while soybean meal provides most of the protein requirement (Krishna et al. 2014). Broiler rations, on an average, contain 64% maize and 20% soybean cake, while layer rations contain 42% maize and 16% soybean cake (Landes et al. 2004).

In India, the growth of the poultry industry has been facilitated by a concomitant surge in domestic maize production (Dixon et al. 2008). Between year 2000 and 2010, the domestic poultry sector in India grew by 141.7%, whereas the maize grain production increased by 93.4% (Table 3). Growth in the poultry industry is fuelling investment in maize cultivation and processing (*Business Today*

2014; Narayanan et al. 2008). In India, maize is now widely available as a low-cost energy source, easily digestible for the birds and highly palatable.

Table 3. Expansion of Poultry and Feed Crop Sectors (Maize, Soybean) in India.

Year	Poultry stock (million birds)	Maize grain production (million tonnes)	Soybean production (million tonnes)
1990	290.60 (72%)	8.96 (74%)	2.60 (49%)
1995	333.50 (82%)	9.53 (79%)	5.10 (97%)
2000	404.40 (100% - base)	12.04 (100% - base)	5.28 (100% - base)
2005	560.34 (139%)	14.71 (122%)	8.27 (157%)
2010	867.87 (214%)	21.73 (180%)	12.74 (241%)
2013	977.50 (242%)	23.29 (193%)	11.94 (226%)

Source. FAOSTAT 2014.
Note. Figures in (brackets) show the value relative to that in 2000.

Up to the late 1980s, maize in India was predominantly (70%) consumed directly as food, with the remainder 30% going to feed and industrial use in about equal proportions (Singh and Pal 1992). Since the 1990s, there has been an increase in the quantity of maize used as feed, whereas non-feed use (including food and industrial use) has remained relatively static. Over 50% of maize production in India is now destined for the poultry industry (Chaudhary et al. 2012; Sethi et al. 2009). From 2007-2011, maize production in India registered an annual growth of 6.4%, the highest amongst all food crops in the country.

Over the last decade, maize output in India in total has grown by 56% (Business Today 2014). During 2012-13, India produced 23.3 million tons of maize grain from 9.5 million hectare of land with an average grain yield of 2.5 tons per hectare (FAOSTAT 2014). Maize production has particularly taken off as a new cash crop in the states of south India, where it is used by the neighboring vertically-integrated poultry companies.

Poultry and Poverty Reduction in India

The Indian poultry revolution is contributing to improved nutrition and poverty reduction (Pica-Ciamarra and Otte 2010). This sector now employs over 3.0 million people. At least 80% of employment in the poultry sector is generated directly by farmers, while 20% is engaged in allied activities like feed production, pharmaceuticals and equipment (Sridharan and Saravanan 2013). An increase in per capita availability of one egg or 50 grams of poultry meat is estimated to create an additional 20-25 thousand jobs (Sridharan and Saravanan 2013). Still, India’s poultry revolution has seen an increasing industrialization and vertical coordination – with still unclear equity implications. Indeed, the potential impact of accelerated growth and the ongoing structural change in the Indian poultry sector on the future of small and marginal producers has been raised.

While the integrated poultry value chains are contributing to a reduction in poverty, small-scale backyard poultry can also provide important supplementary income and is generally perceived as pro-poor and socially inclusive. Small-scale poultry production development system which involves people in production, supply and services and has been depicted as a tool in poverty alleviation (Dolberg 2004). Rearing a small number of birds in a free range system, as in the case of indigenous birds under low input and low output systems, is economical since such birds derive most of their feed from scavenging (Chowdhury 2013). Very small family flocks raised for subsistence consumption and local sale are unlikely to be pushed out of production as long as they will continue to serve a safety net function for the families who own them (McLeod et al. 2009).

The Indian Poultry Industry and Implications for Poultry Trade

Thus far India's poultry sector was primarily a domestic affair whereby it competitively produced both the poultry and its feed domestically to meet the surging demand. Still, the growth of the Indian poultry industry, and the rest of Asia, has led to a decline in North American and European producers' share of the global poultry market. The United States (U.S.) is the world's second largest broiler meat exporter and exports are a significant income source for the U.S. broiler meat industry. As Davis et al. (2013) report, U.S. broiler meat exports have experienced strong growth over the past 16 years. Export shipments of U.S. broiler meat increased just over four percent per year, on average, between 1997 and 2012. Several factors have affected U.S. broiler meat exports and these include increased efficiency in domestic production, income and population growth in destination markets, exchange rate shifts, trade policy and trade conflicts, and relative price changes for other meats (Davis et al. 2013).

Henderson (2015) contends that U.S. exports will depend much on the BRIC countries: Brazil, Russia, India, and China—countries that account for more than 40 percent of the world's consumers. Forecasts suggest the rising demand for protein in BRIC countries will propel U.S. meat exports in the future. Yet, a closer inspection of historical trade patterns with BRIC countries suggests that U.S. protein exporters may struggle to expand their share of these markets – the Indian poultry market being a case in point. Davis et al. (2013) project U.S. broiler meat exports to rise about 12 percent between 2013 and 2022. India is not among their target countries, focus instead is on China and Russia, although demand in Russia is falling and the US faces stiff competition from other exporting countries such as Brazil.

The growing demand for poultry in India has not yet translated into increased meat imports and it may not do so over the coming decade(s). India remains a low-income nation, which limits its demand for meat. While protein consumption increased during the last decade, non-animal proteins accounted for the bulk of India's protein consumption. As a result, Indian's meat imports are practically nonexistent, with only minimal imports of poultry, a lower-priced meat. The increased poultry consumption is expected to be met by increased domestic production. Another reason behind India not importing poultry meat is that unlike many other countries, only about 2-3% of the total poultry meat produced in India is sold as processed meat, reflecting consumers' preference for live chicken and also inadequate processing and storage infrastructure, such as refrigerated transport. This is beginning to change and spending on ready-to-eat meals is rising and a number of poultry firms act as aggregator intermediary and have their own poultry brand in various processed forms for the small but growing domestic market for processed chicken. Still, the live-bird market is most likely to continue to dominate in India at least for next few years.

Given the increasing size of India's poultry sector, its price competiveness and Indian entrepreneurship, India is set to take a more active role in the global poultry trade. Indeed, some of poultry processing firms are starting to target export markets and an increased export market competition from countries such as India can be expected in the future. In summary India has a tremendous potential to play a major role in the international market, hence, representing competition for traditional exporters such as the United States and Brazil. Shanthi Poultry Farm (P) Ltd., for example, is a large integrated poultry group in South India that freezes and packs chicken that conform to stringent international quality norms that cater to international market including the Middle East, Europe and America. Another example is Venky's (India) Ltd. The company sells its processed chicken under the brand name *Venky's*. Venky's is the first national brand in the processed chicken segment and down the years, has become synonymous with nutrition, quality, and high standards in hygiene. It is a preferred supplier to the Indian outlets of McDonalds, KFC, Pizza Hut, and Domino's (Karthikeyanv and Nedunchezhian 2013).

India currently accounts for less than 0.4% of the global trade in poultry. However, poultry meat from India already has a growing market in the Middle East and captured some of these markets following the outbreak of avian bird flu in Southeast Asia in 2003/2004. Furthermore, the Project Directorate on Poultry in India has identified potential markets in a number of countries (Japan, Singapore, Sri Lanka, Poland, Belgium and Australia) for poultry products other than meat, including egg powder and frozen eggs (Directorate on Poultry 2011). India started to export eggs as late as 1996 and whereas in 1995 only 2,640 t were exported, the volume increased to 60,000 t by 2005 (Windhorst 2008). India's export of poultry products has increased from about 517,000 tons in 2010-11 to 578,000 tons in 2012-13. This has implications for countries such as the United States, the leading exporter of poultry meat.

Sustaining India's Poultry Revolution

Feed Market Implications

Some commentators contend that as the BRIC countries increasingly try to satisfy their growing demand for proteins with domestic livestock production, the sharpest gains in U.S. agricultural exports may not emerge from animal products but from feed crops (Henderson 2015). Yet, even these bright opportunities may be dulled as BRIC countries bolster their own grain production, as is very much the case in India.

The sustained availability of low-priced, high-quality feeds in India is critical if poultry production is to remain competitive and to continue to grow to meet the increasing consumer demand for eggs and meat (Ali 2007; Project Directorate on Poultry 2011). Maize is set to remain the preferred energy source for poultry in India. Total maize production in India is expected to continue to grow to 28-44 million tons by 2020, owing largely to demand from the poultry industry (Narayanan et al. 2008). However, maize productivity growth in India is starting to lag demand from the rapidly expanding of poultry sector. Without large increases in maize productivity, India might become a net importer of maize by 2018-2020 (Munro 2014; KPMG 2013). This would have implications for the competitiveness of the poultry industry in India but at the same time it provides opportunities to boost maize production and productivity.

Average Indian maize yields lag world and Asian averages and there are significant maize intensification opportunities to produce even more and cheaper feed. There exists enormous potential in India for investing in research and development (R&D) to enhance maize productivity, including increased use of high-yielding, production risk-reducing improved maize varieties/hybrids. This scenario, in turn, presents significant opportunities for private- and public-sector investments to invest in plant breeding, seed production and marketing, more so given an increasingly favorable policy environment for seed sector development. With the Industrial Licensing Policy of 1987 and the New Policy on Seed Development of 1988, the Indian Government reduced state control over seed production and marketing, and with the New Industrial Policy of 1991 foreign direct investment in the seed industry was allowed (Pray et al. 2001). Since India liberalized seed laws in late 1980s, private seed companies have captured a significant share of the market, especially in southern India (Pal et al. 1998; Singh and Morris 1997).

Alongside ensuring adequate maize volumes for the expanding poultry sector, quality or nutrient composition of the grains as a feed ingredient is equally important to ensure sustainable production of poultry. Protein is one of the major limiting ingredients in the poultry feed mixture. Maize is the major energy source in feed combinations, but it is a poor source of essential amino acids for poultry (Atlin et al. 2011). Currently, the limiting amino acids in poultry diets – methionine, lysine, threonine and tryptophan – are added to poultry feed. However, development and distribution of bio-fortified maize – Quality Protein Maize (QPM) and High Methionine Maize (HMM), containing enhanced levels of limiting amino acids – offers some prospects for the poultry industry by reducing the requirement for synthetic amino acid supplements (Krishna et al. 2014; Lopez-Pereira 1993; Prasanna et al. 2001). Bringing such innovations to market also calls for innovative value chains to capture the quality attributes of feed ingredients from farmers to poultry firms (Hellin and Erenstein 2009).

Environmental and Epidemiological Implications

Projected continued growth of India's poultry industry could be derailed by environmental and epidemiological facts. Livestock intensification has potential environmental externalities. Intensive poultry production implies birds in confined spaces with implications for handling waste and managing pests and diseases. These are aggravated when the intensive production systems cluster geographically, as is the case in southern India. A major problem facing intensive poultry production as in India is the disposal of litter (Bolan et al. 2010). Most of the litter produced by the poultry industry is applied to agricultural land. Poultry litter is a good organic source of nutrients for raising crops, such as maize but it can lead to environmental pollution when the litter is applied under agronomic, soil and climatic conditions that do not lead to the utilization of the manure-borne nutrients (Bolan et al. 2010). Poultry manure can also become a serious environmental pollutant (Gao et al. 2006) and contributor to greenhouse gases (Zhou et al. 2007). In addition, air quality has become a major environmental concern of the poultry industry. There are environmental and health issues linked to bio-aerosols (e.g. microbes, endotoxins and mycotoxins suspended in air) generated at production, manure storage facilities and during land spreading of poultry litter (Bolan et al. 2010).

The rapid growth of the poultry industry in India and other Asian countries has also raised the threat of disease pandemics. Currently there are two avian influenza virus infections that have appeared in domestic poultry and which have caused high human fatality rates, especially in a number of Asian countries: highly pathogenic avian influenza H5N1 (with infected countries widely distributed internationally) and avian influenza H7N9 (confined to China). Both H5N1 and H7N9 have pandemic potential but are currently not contagious among people in their current forms. However, although the international community through its animal health agencies the World Organization for Animal Health and the Food and Agriculture Organization of the United Nations (FAO) have developed comprehensive guidelines for the detection and control of animal influenzas, there is little prospect that the H5N1 and H7N9 infections will be eradicated in affected countries, or that new strains of influenza will be prevented from arising in the rapidly growing poultry industry.

Outbreaks of Avian Influenza is likely to have impacts on production and consumption patterns, resulting in serious financial problems of major producers and new spatial patterns of production and trade flows (Windhorst 2006). Outbreaks of avian influenza virus infections can have detrimental impacts on the poultry industry. Bangladesh, for example, experienced Highly Pathogenic Avian Influenza outbreaks during 2007 and 2008. A total of 547 commercial and 42 backyard flocks were culled with over 1.6 million birds being destroyed. As a result, demand for maize from the feed industry decreased from 3.0 million tons to 2.0- 2.2 million tons (Chakma and Rushton 2008). Disease can also affect a countries ability to export poultry meat (Davis et al. 2013). So far, India has escaped a major disease outbreak.

Conclusions

India has almost doubled its meat consumption during the past decade spurred by domestic economic growth and consumption dynamics. Still, the average Indian only consumes about 4.5 kg (10 pounds) of meat per year, reflecting the country’s low-income status and preference for non-animal protein sources. Poultry occupies a crucial place in India and chicken is the most widely accepted meat in India – helped by religious taboos around beef and pork. Many Indian families in urban areas have begun to accept eggs as a regular supplementary part of their vegetarian diet. The domestic demand for poultry meat and eggs in India is expected to continue to grow at a brisk pace.

A key factor under-pinning India’s poultry industry is the availability of animal feed, particularly maize. Maize production in India is expanding and changing rapidly in response to the growth in the poultry industry. Meanwhile, maize value chains are growing more sophisticated and their changing structure provides investment opportunities for public and private sector actors. Maize thereby helps drive India’s agricultural and economic growth especially through its role as feed for the flourishing poultry industry. An appropriate institutional and policy environment should enable India’s poultry revolution to continue into the future – with due attention for feed market development and the environment.

India’s poultry revolution has already made its mark on global poultry production and trade. The overwhelming majority of the demand in India was and will continue to be met by domestic production – whereby traditional poultry exporters such as the United States and Brazil have largely missed out on India's burgeoning poultry market. Furthermore, India is likely to become a more important player on the export market especially in the Middle East and thereby presents an emerging competitor in the global poultry trade arena.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Factors Driving South African Poultry and Meat Imports[1]

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Abstract

Import demand for poultry has made it South Africa's fastest growing meat product, while demand for beef, sheep, and goat meat is generally declining. Poultry was found to be a statistically significant substitute for pork and other meat (sheep, goat, and offal), but insignificant with respect to beef. Pork tends to be complementary to beef, though statistically insignificant.

The article investigates which of three crucial factors are most affecting South Africa meat imports: (1) changes in consumer tastes and/or meat processing technology, (2) prices, or (3) scales indicating the total size of the imported meat market. Major findings showed that changes in taste-technology had a greater impact on increasing poultry and pork imports than changes in prices, even though poultry prices tended to increase less than the prices of beef, pork, and other meats, making it a better bargain.

Keywords: import demand system, taste-technology, scale, and price, South Africa, poultry, beef, pork, sheep & goat

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[1] The views expressed here are those of the authors, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

Introduction

Animal products are by far the largest agricultural sector in South Africa (SA), contributing 46.4 percent to the total gross value of agricultural production in 2012/13, followed by field crops (28.6 percent), and horticultural products (25.0 percent) (Trends in the Agricultural Sector 2013). Nonetheless, the deficit in the SA balance of trade for meat rose from a low of US $3.8 million in 2002 to US $428 million in 2013 in nominal terms, after reaching a record high of US$546 million dollars in 2012. Although statistical data for 2013 and 2014 showed that the SA meat trade deficit is slightly declining, poultry imports have continued to grow, accounting for over 81 percent of SA total meat imports.

The goal of this research is to explore the key drivers of the South African meat imports, focusing specifically on which of three factors have the most effects on meat imports: prices, scale, or taste-technology. Initially, we estimated the demand shift among various meats in relation to their own prices, cross-prices, and scale elasticities to determine the patterns of consumer demand for different meats and the substitution effects. These elasticities have a number of potential uses. The United States is a major exporter of these four types of meats; the more we know about how the world's meat buyers respond to prices, the better U.S. forecasts and analysis of U.S. meat exports will be. Estimated elasticities could also be used to analyze implications of SA policy changes and reforms affecting the meat trade. In addition, we would expect that South Africa's growing economy will normally lead to expanding consumer demand for meat, and likely to higher imports. Of course, expanding supply could have offset expanding demand. On the other hand, attempts to expand SA's corn and soybean markets could fail and lead to higher domestic feed prices, higher cost of production for domestic meat producers, and higher meat imports from more competitive world markets. Consequently, formal analysis of the role of government policies affecting domestic supply and exports of critical feed commodities requires more focus in future research work.

Over the past few decades, authors in a number of countries have investigated the demand for meat imports in those countries, among them Hayes, Wahl, and Williams (1990) in the United States; Kawashima and Sari (2010) and Yang, and Koo (1994) in Japan; Lopez (2009) in Mexico; Ablayeva et al. (2004) in Russia**;** and Pantzios and Fousekis (1999) in Greece**.** To the authors' knowledge, however, no study has investigated which of three crucial factors are most affecting South Africa meat imports: (1) changes in consumer tastes and/or meat processing technology, (2) prices, or (3) scales.

The following sections describe the SA livestock sector, meat production, meat consumption, and meat imports from 1997 to 2014. It also includes a discussion of the economic literature on SA import demand for meats, documenting a similar shift in consumer preferences from red meat toward poultry in other countries. Following the discussion of economic literature are the methodology, empirical results, and conclusions.

South Africa's Meat Production and Consumption

Total SA meat production nearly tripled from 1,009 million Kg in 1975/76 to over 2,752 million Kg in 2012/13. Bovine was consistently the most produced meat until 1995/96, when poultry outpaced red meats (beef, pork, sheep, and goats). Both red and poultry meats made striking increases over the period, but poultry production was the most impressive, accounting for 56 percent of SA's total meat production. Table 1 shows the shift in total meat consumption from red meats toward poultry. Based on South Africa's official data, per capita consumption of poultry meat surpassed that of the four-red meats in 1997/98 (20.7 Kg versus 20.2 Kg per year). As Table 1 shows, the gap continued to increase in favor of poultry, rising to 35.1 kg in 2010/11, and slightly thereafter to 36.3 Kg in 2012/13. On the other hand, most of the decline in per capita red-meat consumption occurred versus 24.9 kg for red-meat in 2012/2013.

Table 1. Production, Consumption White and Red Meat

	Poultry		**Red Meat**		**Poultry**	**Red Meat**
	Prod.	Cons.	Prod.	Cons.	Per capita Cons.	
	Million Kg				Kilogram	
1975 - 1976	294	290	715	831	13.5	33.1
1980 - 1981	364	338	806	891	14.1	31.7
1985 - 1986	474	474	905	939	17.4	29.8
1990 - 1991	593	593	987	1050	19.4	29.9
1995 - 1996	699	736	740	865	18.7	21.8
2000 - 2001	869	938	736	828	21.5	18.9
2005 - 2006	1143	1383	1060	1162	29.5	24.8
2010 - 2011	1474	1753	1164	1240	35.1	24.8
2011 - 2012	1484	1836	1168	1242	35.5	24.0
2012 - 2013	1529	1899	1223	1297	36.3	24.9

Source. Abstract of Agricultural Statistics, 2014.

South African consumers' shift to poultry from red meats seems similar to the shift among European and U.S. consumers more than 40 years ago, and there are common drivers of change. Generally, these have included rising consumer awareness of healthy and unhealthy eating—e.g., of dietary fat causing high levels of cholesterol—as well as safety concerns following outbreaks of animal diseases, increased emphasis on convenience (time to cook and prepare) for housewives as their participation in the labor market rises, and changes in relative meat prices. These concerns are seemingly correlated with increasing per capita income.

For example, in the United States, health issues (linking fat content and high cholesterol levels and strokes) initiated a change in meat demand from beef to poultry/chicken, lean pork, and fish products (Piggott and Marsh 2004; Moschini and Meilke, 1989; and McGruirk et al. 1995). Similarly, Huston (2000), in discussing reasons for the demand shift from red-meat to poultry, included the factors mentioned above: safety, health issues, convenience (time to cook and prepare), and relative prices. In the United States, some of these factors, if not all, contributed to a decrease in U.S. per capita consumption of beef from 84 to 62.5 pounds per year, and a remarkable increase in chicken from 40 to over 80 pounds, during the period 1970-1999 (Davis and Stewart 2002).

In the UK, the decline in beef and veal consumption during 1990-1998 was attributed to safety concerns about beef as a food, animal welfare and environmental issues, outbreaks of animal diseases, changes in demographics, changes in relative prices, health concerns (fat content), and the demand for convenience (Resurreccion 2003). In other parts of the world, authors reported that changing lifestyles led to the shift toward more convenience in meat and food preparation. Anderson and Shugan (1991) and Grunert (2006) found that consumer demand for convenience boosted demand for poultry relative to beef. Grunert called convenience the most significant trend contributing to rising chicken sales.

Increasingly, fat content in meat is generally seen as negative. This was confirmed in four European countries; France, Germany, Spain, and the UK (Grunert 1997), as well as in South Africa (Shongwe et al. 2007). Also in South Africa, Nieuwoudt (1998) and Louw et al. (2010) explained changing demand for meat in general to growth in population and per capita income, urbanization, and food preferences among different racial groups. Louw et al. also explained the rise in demand for poultry to "global derived factors," including health concerns, expansion of fast food outlets, and demand for convenience.

Taljaard, et al. (2006) also examined the factors driving South Africa's demand for meat. Their econometric models included prices, income, and a group of taste effects measuring consumer demands for health and safety, convenience, quality, animal welfare and the environment. Taljaard et al. split their sample into two separate periods: 1970-1988 and 1985-2003. Prices and income were the most important drivers of demand in the first period; the group of taste factors was the most important in the later period, when taste-technology was one among a group of several factors but was not the standout factor.

Economists widely believe that demand for poultry is rising mainly because it has the lowest relative prices of all major meats. Does this apply to South Africa, where poultry imports averaged over 81 percent of total meat imports over the last five years? This article concentrates on this question, namely, investigating which of three factors is most strongly effecting changes in import demand for meats in South Africa; prices, scale, or taste-technology.

Commercial Meat Trade

Total meat imports to South Arica increased 124 percent, but poultry rose the most: 281 percent from 1997 to 2014. During the last five years (2010-2014), the rise in poultry meat imports brought them to over 81 percent of SA's total imports, followed by other meat (9 percent), beef (2 percent), and pork (6 percent) (Table 2).

In 2014, about 48 percent of the SA poultry imports originated from the EU-27, 43 percent from Brazil, 5 percent from Argentina, and only 1.3 percent from the United States. This was mainly due to the Anti-dumping duties case against U.S. poultry products and the imposition in 2000 of anti-dumping tariffs, amounting from Rand 2.24/ kg to 6.96/kg (US $0.32 to US $1.00), in addition to an import duty of Rand 2.20/kg (US $0.31/kg) (USDA-FAS Gain Report, Republic of South Africa 2011).

Table 2. South Africa's Meat Imports, 1997-2014

	Poultry	Beef	Pork	Other	Total
			Million Kilogram		
1997	103	48	6	58	216
1998	87	16	7	53	163
1999	98	16	12	58	184
2000	93	13	11	72	190
2001	78	5	9	51	143
2002	94	4	8	35	141
2003	153	10	18	33	214
2004	182	16	22	37	257
2005	214	20	27	46	307
2006	294	19	21	56	389
2007	276	17	23	58	374
2008	220	7	18	51	296
2009	231	10	27	44	311
2010	265	6	26	42	339
2011	349	11	32	41	433
2012	403	7	33	39	482
2013	389	6	27	38	461
2014	393	24	19	48	483

Source. World Trade Atlas, February 2015

Meat exports from South Africa, albeit small, more than tripled from $US 133.6 million in 2010 to $US 254.3 million in 2014, mostly shipped to neighboring African countries in 2014. Exports in 2014 consisted of 45 percent beef and 34 percent poultry, with the remaining 21 percent consisting of other, i.e., pork, sheep, and goat meat and offal.

Statistical Analysis of South African Import Demands

The analysis of South African meat imports has two basic goals:

1. To determine what factors are driving SA poultry imports. As noted, previous studies have typically agreed that the low relative price of poultry has been a driver of increased poultry demand, as would be expected, while several of the studies found that taste shifts have also contributed to the increase. In this article, we develop a model simulation to determine which of the following three factors has the most effect on South African meat imports (1) taste-shift, (2) prices, or (3) scales.

2. To estimate South Africa's meat import demand system to provide support for future work. We can use these model estimates to calculate South Africa's meat import demand elasticities. These elasticities have a number of potential uses. The United States is a major exporter of these 4 types of meats; the more we know about how the world's meat buyers respond to prices, the better U.S. forecasts and analysis of U.S. meat exports will be. In addition, these elasticities could also be used to analyze implications of SA policy changes and reforms affecting the meat trade.

Modeling SA Meat Import Demand System

The study used the Central Bureau of Statistics (CBS) model developed by Keller and Van Driel in 1985. The name refers to the authors' employer, the Dutch Central Bureau of Statistics. The CBS model is essentially conditional on the "scale" of meat imports, where scale is a measure of the total outputs produced using the imported meats. The CBS model was augmented by adding a trend variable to cover changes in consumer demand, triggered by consumers' rising preference for certain meat.

The demand for inputs can be changed by both shifts in consumer demand for outputs and by changes in the technology used to produce those outputs. Economic analysts often use time trends to model taste and/or technology shifts. Trend terms imply constant, straight-line growth over time. Additionally, consumer demand for meat products could change the demand for the meat imports used to make them. Changes in meat processing technology could also encourage meat importers to shift among the types of meat.

This sort of straight-line change in taste or technology effects is rather simplistic; however, we allowed for a more complex pattern by adding a squared-trend term to the model. A squared trend gives us a more flexible taste-technology shift. A pure trend will either constantly increase or decrease the demand for a product. By adding a squared-trend in the model, we can have reversals in the taste and technology shifts. For example, demand for one of the imports could grow early on, then reverse and begin to decline later on during a certain time period. Together, the trend and squared-trend terms measure the effect of changes in tastes and/or technology[2].

Keller and Van Driel originally developed the CBS system to model consumer demands. Meat imports are intermediate goods: they must be further processed before sale to consumers. Prior to the development of the CBS model, Theil (1977) showed that consumer demand models are also consistent with cost-minimizing input demand.

All differential demand systems use the total differential of the budget constraint:

$$(1)\quad \partial\left(\sum_i q_i p_i = x\right) \rightarrow \sum_i w_i \partial \ln p_i + \sum_i w_i \partial \ln q_i = \partial \ln x,$$

where q_i and p_i are the quantity and price of good i, x is the total expenditure, or in the case of derived demand, the total cost of inputs, and $\partial \ln\cdot$ stands for the change in the natural logarithm of the term "·". The term w_i is the budget share for product "i", defined as:

[2] The CBS model also included seasonal demand shifters. These seasonal shifters measure how one month's demand for a type of meat differs from others. It seems more likely that these would be driven by shifts in consumer tastes rather than technology. As we set these up, these monthly shifters only cause imports to vary month-to-month and not over longer periods of time. Our discussion of these is limited given our focus on the long-term drivers of import demand.

$$(2)\ w_i = \frac{p_i q_i}{x}.$$

The summation terms in equation (1) are often replaced with divisia price and quantity indices, defined as:

$$(3)\ \partial P = \sum_i w_i \partial \ln p_i\ ,$$

$$(4)\ \partial Q = \sum_i w_i \partial \ln q_i\ .$$

Equations (3) and (4) can be inserted in (1) and rearranged to produce:

$$(5)\ \partial \ln x - \partial P = \partial Q\ .$$

In their development of the Central Bureau of Statistics (CBS) model, Keller and Van Driel (1985) used equation (6) below, which is a more appealing version from the standpoint of consumer theory. In a derived demand context of the current analysis, equation (6a) is more convenient. Actually the forms in (6) and (6a) are equivalent; one simply uses different sides of equation (5) in the specification.

$$(6)\ \ w_i \cdot \left[\partial \ln q_i - \partial Q\right] = \sum c_{i,j} \partial \ln p_j + b_i \left[\partial \ln x - \partial P\right], \text{ or}$$

$$(6a)\ w_i \cdot \left[\partial \ln q_i - \partial Q\right] = \sum c_{i,j} \partial \ln p_j + b_i \partial Q\ .$$

Theil (1977) showed that changes in the divisia quantity index corresponded to changes in total output. The coefficient b_i, which multiplies the quantity index in (6a), shows how demand for an input responds to changes in the total output. As is common in applied demand analysis, we will refer to the b_i as “scale” terms. If all the b_i’s are 0, the technology has constant returns to scale. Negative b_i implies that the cost share (the w) for input “i” decreases as the total scale of output increases, and vice versa. The cross-price elasticities (c_{ij} coefficients) show how quantity “i” reacts to changes in the price of “j.” The c_{ij} also include c_{ii}. These coefficients can be used with the budget share to derive price and scale elasticities of demand using the following formulas:

$$(7)\ \varepsilon_{ij} = \frac{c_{ij}}{w_i}$$

$$(8)\ \eta_i = 1 + \frac{b_i}{w_i}\ .$$

In (7) and (8), ε_{ij} is the elasticity of demand for input i and price j and η_i is input i’s scale elasticity of demand.

Keller and Van Driel demonstrated that the CBS model is a locally flexible functional form. One can take any set of demand elasticities and find a set of CBS coefficients consistent with these elasticities. In order to be consistent with optimization, the coefficients have to be homogenous of degree 0, consistent with the budget or total-cost constraint defined in equation (1) and symmetric. This will be true if the following two equations hold:

$$(9)\ \sum_i c_{ij} = 0 \forall j,$$

$$(10)\ \sum_i b_i = 0.$$

Equations (9) and (10) imply that the c_{ij} and the b_i coefficients sum to 0 when added over all the inputs. Other constraints require demand to be homogeneous of degree 0 in prices-expenditures and symmetric, as shown in equation (11) and (12), respectively:

$$(11)\ \sum_j c_{ij} = 0 \forall i,$$

$$(12)\ c_{ij} = c_{ji} \forall i, j.$$

All constraints in equations (9-12) are linear equality restrictions. Optimal cost-minimizing demand derivatives also have to be negative semi-definite (NSD) in prices. The CBS system is globally NSD when the matrix of c_{ij}, is itself NSD, which could be achieved by imposing economic restrictions of equations (9-12) on all CBS estimations. One implication of demands being NSD is that their own-price elasticities of demand are negative.

The economic drivers for this demand system are the import prices of the 4-meats, and "scale." "Scale" is an economic measure of the final amount of products meat importers make from a certain quantity of imported meat. The scale of the market is going to be determined by a larger set of internal and external economic factors; internally, they include supply, demand, and policy conditions, and externally, the prices paid for meat imports.

Estimation Forms for the CBS Model and Preliminary Tests

The CBS and other differential models of demand start with demand derivatives. Demand derivatives are not observed; prices and quantities are. The CBS models are estimated under the assumption one can approximate the differential equations with finite differences. A general way to write the difference equation would be:

$$(13)\ w_{it}\left[Ln\left[\frac{q_{i,t}}{q_{i,b}}\right] - \sum_j w_j Ln\left[\frac{q_{j,t}}{q_{j,b}}\right]\right] = y_{it} = \sum_k H_{k,t} * d_{i,k}\ .$$

$$\sum_j c_{ij} Ln\left[\frac{p_{j,t}}{p_{j,b}}\right] + b_j\left(Ln\left[\frac{X_t}{X_b}\right] - \sum_j w_{jt} Ln\left[\frac{p_{j,t}}{p_{j,b}}\right]\right) + e_{it}$$

The terms $q_{i,t}$ $p_{i,t}$ and X_t are actual quantities, prices and expenditures for a specific month. The $q_{i,b}$ $p_{i,b}$ and X_b are the baseline values; the baseline expenditure is consistent with the baseline prices and quantities. The term $e_{i,t}$ is a random error term. By virtue of the model's construction, the error terms in each time period sum to 0.

The $H_{k,t}$ are a set of other exogenous variables that act as taste-technology shifters; the $d_{i,k}$ are estimated coefficients, which have to sum to 0 over "i" for each "k" if the budget constraint is to hold. The H variables include an intercept, a trend, a squared trend, and 12 monthly dummies. The intercept and monthly dummies are perfectly collinear, so the dummies' coefficients are identified by making each meat's set of monthly dummies sum to 0 when summed over the year. Unlike the other terms in (13), the $H_{k,t}$ are not explicitly differenced from a baseline. The interpretation of the intercept and error depends on what one uses as a baseline. The most common baseline used in this type of demand analysis is last period's value; for example $q^b_{i,t}$ would be $q_{i,t-1}$. In this type of non-linear first-difference approach, the intercept would represent the difference of a trend, and the intercept's coefficient is generally interpreted as a taste-change variable.

This analysis follows Hahn and Mathews (2007), who used a non-lagged baseline to calculate average prices and quantities to create baseline prices, quantities, shares, and expenditures. This type of formulation is based on the assumption that average quantities are optimal given average prices, which might not be the case. The intercept terms in this case can be interpreted as correcting the baseline quantities or measuring the shift necessary to make them optimal. The monthly dummies allow for some monthly variation in this "correction." The intercept can be interpreted as the average correction for the year; the dummies are the seasonal variance from that average. If the monthly dummy coefficient for a product is 0, that product's demand is at its yearly average level in that month. The trend and trend-squared terms allow shifts in demand[3]. Because these are derived demands, the demand shifts can be due to both changes in consumer tastes and meat-processing technology. If the trend and squared trend coefficients are all 0, there are no taste-technology shifts.

Also, like Hahn and Mathews, we specified our error term as a vector autoregressive (VAR) process:

$$(14) \qquad e_{i,t} = \sum_{k=1}^{3} v_{i,j,k} e_{j,t-k} + u_{i,t}$$

In (14), the term $v_{i,j,k}$ is the estimated effect of the k-lag of demand "j" on the current error for demand "i", while $u_{i,t}$ stands for an identically, independently distributed random component[4]. The initial runs used a 3rd-order VAR. Because of the construction of the endogenous variables, the errors, e, and u, also sum to 0 over equations in each time period. The sum of the $v_{i,j,k}$ over "i" is also 0 for each j,k pair. The current and lagged errors are perfectly collinear. To identity the $v_{i,j,k}$ the "j" subscript is defined for only three of the four quantities.

It has long been determined (Barten 1969) that the solution to estimating systems with singular errors is to estimate the model using all but one of the equations, then using the economic restrictions to estimate the parameters associated with the dropped equation. If one uses Full Information Maximum Likelihood estimation (FIML), the estimates are independent of the excluded equation.

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[3] Using both a trend and its square gives us more flexibility in modeling the pattern of shifts.

[4] The "$u_{i,,t}$'s" are independently distributed over time; they will have covariance over equations.

Model Structure Testing

Prior to developing the final-form model on which this analysis is based, we dealt with a number of side issues. For example, were the taste-technology shifters statistically significant? Results showed that all four types of meats had statistically significant trends. Additionally, beef and pork had statistically significant squared-trends (Table 5). This indicated that taste-technology changes were experienced in all four meat types, and squared-trends were experienced in beef and pork. The implication of these two changes was a steady rise in the imports of poultry and a steady decline in other meats. Imports of pork were initially increasing, but later on declined, as a result of the statistically significantly squared-trend. For the same reasons, beef imports were initially declining, then changed course in the last few years.

The empirical results presented next are based on a simpler model than that outlined in equations (13) and (14), which have a large number of parameters in it. We were aggressive in restricting the model and eliminating terms from the model. We have already mentioned that we restricted the quadratic parts of the shifters; poultry and other-meat quadratic terms were statistically insignificant. The following restrictions were imposed on the model:

- We were able to eliminate the 2nd and 3rd lags from the VAR error terms and greatly restrict the 1st-order terms. The pork, poultry, and other meat's "VAR" had only their own lagged error; beef had all three lagged errors. The most common method for putting auto regression in these demand models was developed by Berndt and Savin (1975), and it uses a "diagonal" type structure, as we found with a common set of autoregressive coefficients. We were able to reject this diagonal structure; the lagged-error coefficients for pork, poultry, and other meats are statistically significantly different from each other.

- We started with 12 monthly dummies and managed to eliminate most of them from the model. Only January, August, September, November, and December have significant dummies, and each of these matters for only 2 of the meats. The two meats that matter vary by the monthly dummy.

Data Sources

South Africa's monthly data were compiled from the World Trade Atlas covering the period January 1997-October 2010.Data included volumes and prices (unit-values) of each meat category. Meat imports were divided into four categories: poultry; beef; pork; and all other meats. Other meat's category included sheep, goat, edible animal offal, horses, asses, and mules; salted, dried or cured meat; and animal fat. A unit value ($US per kilogram) was calculated as a weighted average for each of the four categories.

Empirical Results

Table 3 has the "R-square," a measure of how well the model explains the data. An R-square of 100% means that the model fits the data perfectly. There are two versions of the R-square, shown in Table 3. The first column shows the fit relative to the CBS endogenous variable as defined in equation (13). As seen in (13), this endogenous variable is a complicated function of the actual quantities. We used the simulation model that created Figures 1 to 4 to turn the predicted CBS endogenous into predicted quantities. The fits for the actual quantities are quite good for a non-linear model of this type.

Table 3. R-squares in Percent's Relative the Naïve Model

	CBS Endogenous Variable	Quantity Via Simulation
Beef	83.14	42.83
Pork	60.40	57.64
Poultry	78.87	86.97
Other meat	86.52	57.20

Demand shift among various meats, their own prices, cross-price, and scale elasticities were estimated and are used to examine patterns of consumer demand for the different meats and substitution effects in the South African meat demand system (Table 4). Because the price terms are symmetric, we show only the upper triangular part of their matrix. Note that our use of Z statistics is somewhat misleading. For example, the own-price term for beef appears to be statistically insignificant, but in fact it is not, because we required the $c_{i,j}$ coefficient matrix to be negative-semi-definite (NSD) in the model. However, all of the Monte Carlo iterations of the beef own-price term were negative and statistically significant.

Poultry was found to be a statistically significant substitute for pork, sheep/goat, and offal meats, but not significant with respect to beef. Also, pork tends to be complementary to beef, but was statistically insignificant. Most likely, the insignificant relationships are due to small beef imports, averaging 2.4 percent of all meat imports over the last 10 years. Table 5 has the intercept, trend, squared trend, and monthly dummy terms.

Table 6 shows the cost-minimizing elasticities of demand. These are calculated using the coefficient estimates from Table 4 and equations (7) and (8). The price-elasticities of demand show how each import will respond to changes in each price. Most of these elasticities are small. Our price-based simulations can only have large impacts on demand if there are large shifts in the relative prices. Import demand would appear to be sensitive to changes in total market scale.

Table 4. The Price and Scale Estimates for the SA Meat Import Demand System

		Own- and Cross-Price Estimates				Scale
		Beef	**Pork**	**Poultry**	**Other**	**or bi**
Beef	Estimate	-0.0032	-0.0107	0.0022	0.0116	0.0449
	Z-stat.	-0.45	-1.21	0.18	1.24	3.34
Pork	Estimate		-0.0818	0.0805	0.012	-0.0194
	Z-stat.		-4.77	4.31	0.86	-1.33
Poultry	Estimate			-0.1182	0.0355	0.0031
	Z-stat.			-3.77	1.72	0.14
Other	Estimate				-0.0591	-0.0285
	Z-stat.				-2.46	-2.03

Note. [1] Standard deviations and Z statistics are a based on 5,000 Monte Carlo iterations.
[2] Z-stat. means Z-Statistics

Table 5. Intercepts, Demand Shifters, and Seasonal Terms[1]

Meat	Beef		Pork		Poultry		Other	
	Estimate	Z-stat.	Estimate	Z-stat.	Estimate	Z-stat.	Estimate	Z-stat.
Intercept	0.1622	7.19	-0.1164	-5.68	-0.1601	-5.82	0.1143	4.65
Trend	-0.547	-7.09	0.4443	5.98	0.2918	6.2	-0.1892	-4.54
Trend squared	0.334	4.9	-0.334	-4.9				
January			-0.0212	-6.31			0.0212	6.31
August					0.0145	3.17	-0.0145	-3.17
September					0.0067	1.46	-0.0067	-1.46
November	-0.0212	-6.31	0.0212	6.31				
December	0.0212	6.31			-0.0212	-6.31		

Note. [1] Only 5 of the monthly dummies are statistically significant. All of the 5 monthly dummies sum to 0 for each meat-kind.
[2] Standard deviations and Z statistics
[3] Z-stat. means Z-Statistics

Model Simulation: Which of the Three Variables Are Driving SA Meat Imports the Most?

The CBS has a number of desirable features one likes to see in a demand system, but it has one major drawback: it uses a rather convoluted function of quantities. We used a simulation model that allowed us to turn the changes in prices, scale, and the taste-technology shifters into changes in quantities imported. When running these simulations, we started with a baseline import level. The baseline level for each meat is approximately the amount imported at the average prices and scale. The simulations keep all other parameters constant (***ceteris paribus***) and then estimate import demand using each month's actual (1) taste-shift, (2) prices, or (3) scales. Results were depicted for each meat kind in comparison to SA's actual import demand levels.

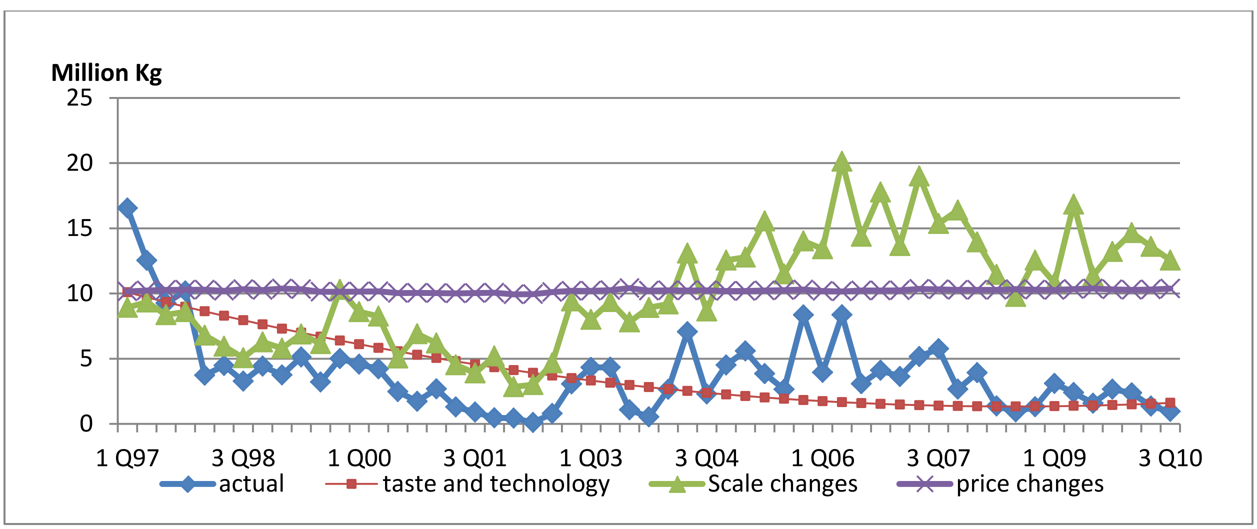

Figure 1. Beef Imports, 1997-2010

Figure 1 shows that actual beef imports were highest early in the sample and lowest in 2001-2002. Beef had both the linear and quadratic taste and technology shifters. Its shifter effect is a smoothly curved line that declines throughout the early-year periods, turning up slightly sometime in 2003-2009.

As shown in Table 6, beef has the highest scale elasticity of all the meats and generally the smallest changes in own and cross-price elasticities. This indicates that price changes have small effects on beef imports, while scale changes have larger effects. Between 2001 and 2002 when beef imports were at their lowest levels, both the taste-technology and scale effects were contributing to lowering beef imports. However, in 2003, beef imports started to increase and were largely driven by the increasing scale of South African total meat imports.

Table 6. Cost-Minimizing Import Demand Elasticities[1]

	Price Elasticities				
Meat	**Beef**	**Pork**	**Poultry**	**Other**	**Scale**
Beef	-0.033	-0.112	0.023	0.122	1.47
Pork	-0.07	-0.54	0.531	0.079	0.872
Poultry	0.004	0.147	-0.216	0.065	1.006
Other meats	0.056	0.058	0.172	-0.287	0.862

Note. [1]Estimates based on World-Trade Atlas Data, February 2015.

Pork also has a quadratic taste-technology term. The remaining two meats have only linear effects. Pork's quadratic has to offset beef's quadratic. As illustrated in the case of beef (Figure 1), beef's quadratic trend caused its taste-technology shifter to have a valley pattern; pork's quadratic trend made it looks like a hill (see Figure 2). Pork is much less sensitive to scale changes than beef but more sensitive to price changes.

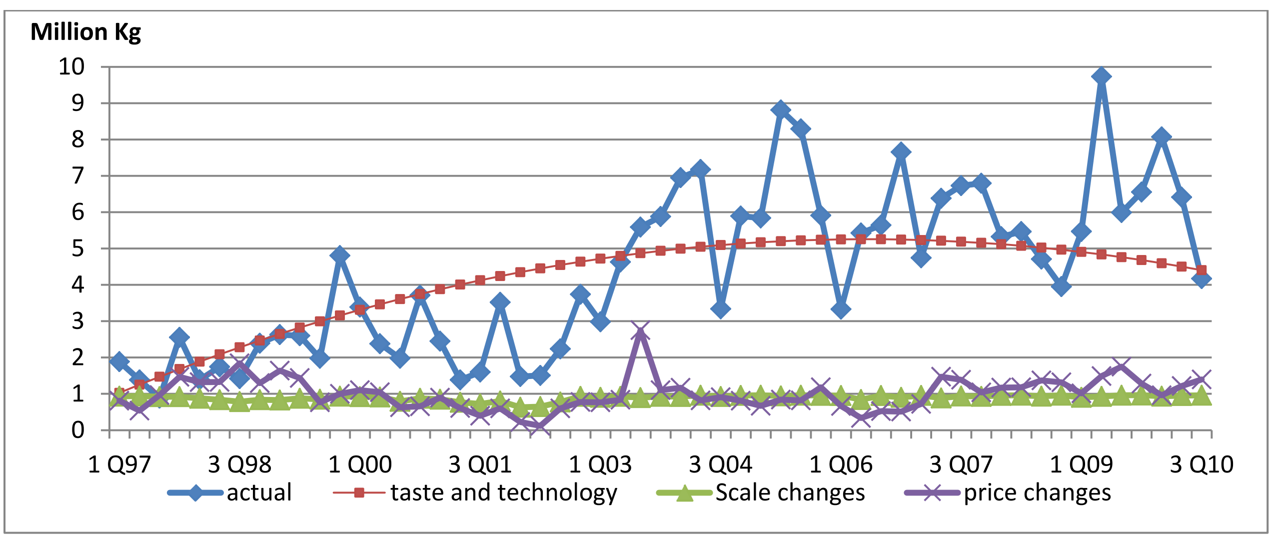

Figure 2. Pork imports, 1997-1010

Like beef, poultry imports are relatively responsive to changes in scale. South African poultry imports have increased, albeit irregularly, throughout the sample period (Figure 3). Poultry's taste-technology effect is purely linear and implies increasing poultry imports. Changes in scale over time have increased poultry demand as well, since 2003. While poultry is more price-responsive than beef, as with beef, price changes have had small effects on poultry imports.

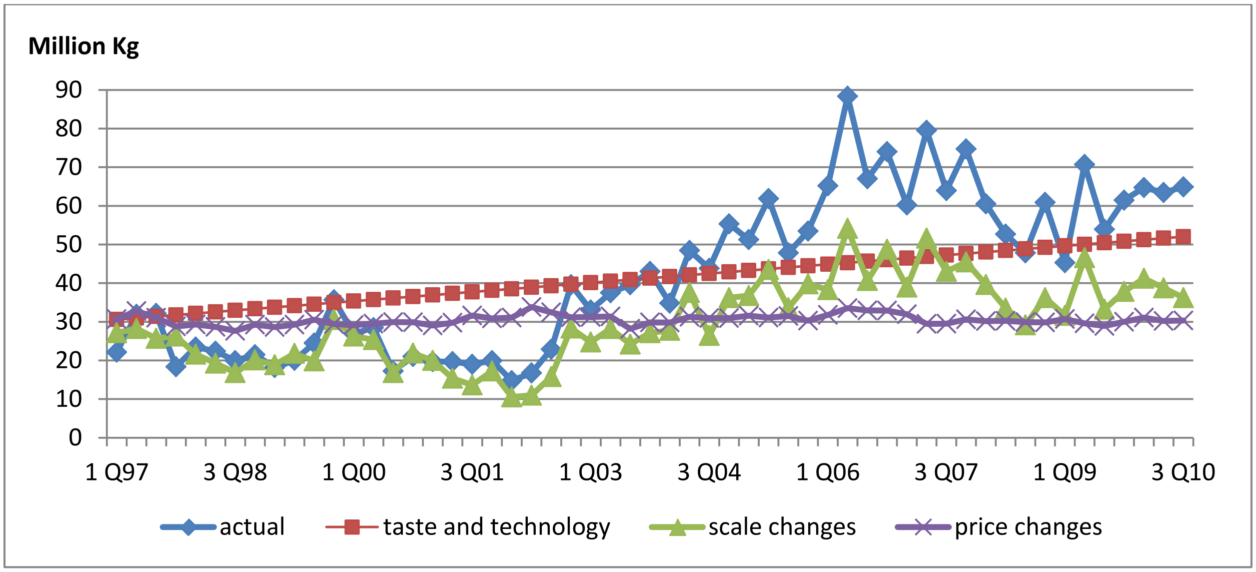

Figure 3. Poultry imports, 1997-2012

Figure 4 shows the results for other meats. Its import pattern mirrors beef: relatively high at the beginning, low in the middle, with some recovery toward the end. Like beef, both the declining tastes effect and the scale effect work together early-on to lower its demand. Toward the end of our sample, the shifter and scale effects go mostly in the opposite directions.

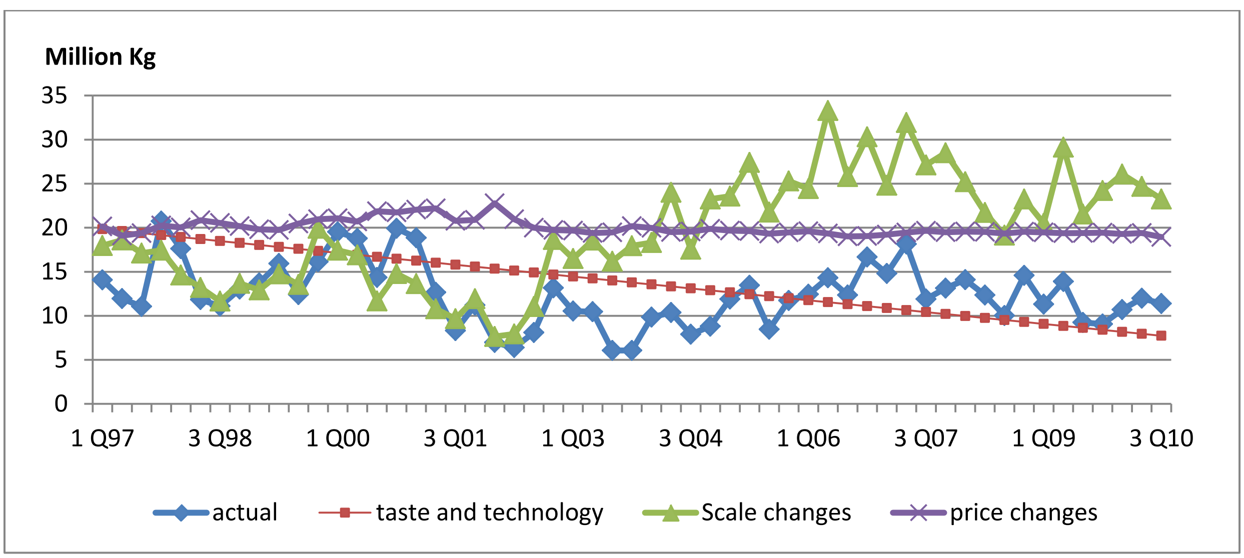

Figure 4. Other meat Imports, 1997-2010

As noted in our literature review, poultry consumption has grown rapidly worldwide. Studies of poultry demand invariably find that its relatively low price is a major factor in its expansion; poultry prices have tended to increase less than the prices of red meats, making it a better bargain. In contrast and unlike all previous studies, our estimates show that poultry prices have had small effects on the long-term trends in South African meat imports, while taste shifts have the largest effects on SA rising demand for poultry meat imports. Of all meat, only pork is extremely sensitive to price changes, which make pork imports more volatile.

The fact that taste or technology changes have increased the imports of poultry is consistent with the results of demand studies in other countries, as noted in our literature review. Moreover, we found similar, if not identical explanations of what is driving these changes. As in several countries cited in the literature review, poultry in South Africa is perceived to be healthier than all other meats. Increasing health concerns are an example of a taste shift. Other studies have found that more convenient, ready-to-cook cuts of poultry have also increased its demand. Part of the added convenience appeals to consumers, shifting their tastes; much of the added convenience is the result of changing processing technology.

The total scale of meat imports is an important driver for at least three of the four types of meats. Although no formal analysis of factors driving meat import scale has been discussed here, we would expect that South Africa's growing economy will normally lead to expanding consumer demand for meat. This expanding consumer demand could lead to higher imports. Of course, expanding supply could offset expanding demand. Attempts to expand and stabilize SA's corn and soybean markets failed, which led to higher domestic feed prices and higher costs of production for domestic meat producers, making them less competitive in world markets. More analysis of the agricultural supply, demand, and policy conditions in South Africa would be valuable.

Finally, a complete structural model would be able to analyze SA's feed-meat complex, one that would include agricultural supply and demand for feed grains such as yellow corn, sorghum, and millet, oilseeds or oilseed-meals, including soybean seeds, sunflower seeds, cotton seeds, rapeseeds, and flaxseeds. The model might usefully include SA agricultural policies, especially domestic policies relating to trade in general and specifically to export parity pricing and import parity prices. However, this article is based on a statistical model (CBS model), and is based on time-series meat import statistical data since 1997.

Conclusions

This article used the Central Bureau of Statistics (CBS) model developed by Keller and Van Driel in 1985, due to several advantages entailed in the CBS model. A demand model is linear in its parameters and restrictions. The CBS model was used to estimate acceleration in meat imports, the patterns of consumer demand for meats by kind, own-price, cross-price, scale elasticities, and substitution and/or complementary effects. We also augmented the analysis using a conditional demand model, adding a trend and trend-square variables to capture possible changes in meat imports since 1997. We specifically focused on three possible shifts that might be triggered by consumers' rising preference for certain meat, due to changes in taste-technology, in meat prices, and in market scales to explore which of these is the most influential in South Africa.

Poultry was found to be a statistically significant substitute for pork, sheep/goat, and offal meats, but not significant with respect to beef. Beef and pork tend to have a complementary relationship, albeit statistically insignificant. Most likely, the insignificant relationships are due to beef small imports, averaging 2.4 percent of all meat imports over the last 10 years. All the model's scale elasticities are positive, indicating that demand for all 4 products grows as the market expands. Increases (decreases) in scale are the only parameters that may expand (contract) the imports of all products simultaneously.

The simulation model also shows that taste-technology and market scale had greater impact on SA meat imports specifically poultry imports than changes in meat prices. More specifically, taste-technology effect was purely linear that increases poultry imports and decreases other meat imports. Beef had both linear and quadratic taste-technology shifters, and as a result beef imports were trending downward up to one point in later years (see figure 1). Pork has only a quadratic taste-technology term, making its imports trend upwards. Pork's quadratic effect has to offset beef's quadratic effect, leaving pork up slightly.

The simulation model also shows that taste-technology had a greater impact on rising SA import demand for poultry than changes in poultry prices. In part, however, the growth in poultry imports is driven by the fact that its price has increased less than the price of red meats, making it a better bargain.

The fact that taste and/or technology changes have increased the imports of poultry is consistent with the results of demand studies in other countries, as mentioned in the literature review. This is because worldwide, poultry is perceived to be healthier than other meats, and increasing health concern is an example of a taste shift.

Lastly, the simulation model showed that price changes have small effects on poultry, beef, and other meat imports, while pork is more sensitive to price changes and poultry is more price-responsive than beef. Therefore, price changes have had smaller effects on poultry imports than on imports of beef, pork, and other meat. In general, poultry prices have tended to increase less than the price of red meats. The analysis helps to explain why South Africa's poultry imports grew from 48 percent of South Africa's meat imports in 1997 to 81 percent in 2014.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Can Mastitis 'Contaminate' Poultry? Evidence on the Transmission of Volatility between Poultry and Other Commodity Prices

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Abstract

This paper analyzes the volatility transmission between poultry and other commodity prices. The main question it addresses is as follows: Is there any commonality in the volatility processes of poultry and other agricultural food commodities' prices? Using standard dispersion indicators to measure the degree of poultry prices volatility and the GARCH-type models to specify poultry international price volatility at time 't' as a function of lagged shocks, we obtain the following results: poultry prices experienced less volatility in recent years relatively to other commodity prices; and the transmission of price volatility from other commodities to poultry prices is rather weak. These results could help to design better risk management tools in agribusiness.

Keywords: poultry, commodity prices, volatility, transmission

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Introduction

After the 2007-2008 large changes in food prices, a huge amount of literature has burgeoned in recent years concerning international price volatility. The volatility of commodity prices in international markets makes business unpredictable and increases the degree of risk faced by economic agents. In fact, financial planning could become more difficult leading to both economic and financial uncertainty in the management of agribusinesses. The analyses of risk management generally focus on the best design of insurance or on portfolio allocation and other income stabilization tools used to help economic agents to cope with volatility. At the public level, policy interventions are designed either to stabilize prices or to diversify risk. Risk diversification can act as insurance only if the shocks are idiosyncratic and if the propagation of volatility between commodity prices is limited. However, little is known about the transmission of price volatility between different agricultural products. Yet, the degree of volatility is not the same for all commodities. While globally the food price index has shown to be more volatile over the last years, the evolution seems to be different among different commodities. The analysis of international poultry prices for instance didn't clearly show an increased instability during the period that follows the 2008 global price spike. Poultry prices, although upward sloping, remained fairly stable (Figure1). This fact corroborates the result obtained by Ano Sujithan et al. (2014) who noted that 'volatility peaks are not simultaneous inside the set of food commodities and that not all were more volatile during the 2007-2008 and 2010-2011 prices surges'. At the same time, trade in the global poultry sector has continuously increased during this period.

Nevertheless, on the question of whether volatility is increasing over time for all commodities, the literature is not very prolific. Therefore, this paper tries to analyze the volatility transmission between poultry and other commodity prices. The main question it addresses is as follows: Is there any commonality in the volatility processes of poultry and other agricultural food commodities' prices?

The analysis of the transmission of volatility has been more prolific in finance disciplines. Volatility spillovers arise because of information flows between different markets (Ross 1989). Therefore, as commodity markets become more integrated, risk and uncertainty can spread from one commodity market to another leading to a transmission of crises between segments of agribusiness sector. For instance, shocks on the dairy production activity like the appearance of a cattle disease (Mastitis for example), can contaminate poultry trade and production through the propagation of price volatility and uncertainty. However, preliminary look at the empirical data tends to astonishingly show that the poultry sector seems to have been preserved from the 2007-2008 and 2010-2011 global commodity price volatility. Hence, this paper tries firstly to analyze the degree of volatility of international poultry prices comparatively to that of other food prices; and, secondly to analyze the price volatility transmission between poultry and some substitute and complement agricultural food commodities' prices.

Following this introduction, the second section presents the methodologies that will be used to analyze the transmission of price volatility. The third section presents results while the fourth section gives some implications deriving from these empirical findings. The last section concludes the paper.

Data and Empirical Method

The empirical method of this paper consists firstly on measuring the degree of volatility of poultry prices in order to compare it to that of other commodities; and, secondly, on modeling the variance transmission.

Measuring Price Volatility

Following Ano Sujithan et al. (2014), this paper uses standard dispersion indicators to measure the degree of poultry prices volatility and to compare it to the dynamics of other agricultural food commodities' price volatility. More precisely, we can use either the conditional variance or the standard deviation to analyze the degree of volatility of international poultry prices comparatively to that of other food prices. To have a unit-free measure of the volatility of commodity prices, the empirical literature generally uses the standard deviation of the natural logs of prices which has been shown to be approximately equal to the coefficient of variation (Gilbert and Morgan 2010). In fact, the main problem arising when we measure the volatility is that price series generally have trends so that in this measurement exercise, we need to be sure that trend movements are not included in the volatility measure. However, detrending price series could induce some arbitrary choices about the trend model; and this could reduce the robustness of the volatility measure. To get rid of these undesirable weaknesses, empirical literature conventionally measures volatility as the standard deviation of changes in logarithmic prices (or price returns). Therefore, this paper follows this convention and measure volatility as the standard deviation of changes in natural logs of prices.

To compute the conditional variance (from which we will derive, at each date in the sample, the standard deviation), we adopt the generalized autoregressive conditional heteroscedasticity (GARCH) framework where observed lead and/or lag relations give the causality in the second moments. GARCH models are the most used procedure of modeling and forecasting conditional variances in financial markets. Introduced by Engle (1982) and generalized by Bollerslev (1986), these models specify an autoregressive moving average process for the variance process followed by a time series. The variance of the dependent variable is modeled at each date as a function of past values of the dependent variable and other explanatory variables.

The dataset used includes monthly commodity price data over the period from January 1980 to July 2013. We collect these data on world commodity prices from the International Monetary Fund (IMF) commodity prices database online at www.imf.org/external/np/res/commod/index.aspx. The set of commodity prices used includes: poultry prices, beef prices, fish meal prices, a food price index including cereal, vegetable oils, meat, seafood, sugar, bananas, and oranges price indices. We will also consider non-food commodities like the energy price index including crude oil (petroleum), natural gas, and coal price indices; and an all-commodity price index including both fuel and non-fuel price indices.

Poultry prices are chicken's whole bird spot prices, ready-to-cook and iced; expressed in US cents per pound. Beef prices are cost, insurance and freight (CIF) U.S. import prices of Australian and New Zealand 85% lean fores, expressed in US cents per pound. Fish meal prices are 65% protein pellets of Peru fish meal cost, insurance and freight (CIF) U.S. import prices, expressed in US Dollar per metric ton. The energy price index is an aggregated price index of fuel (2005=100) including crude oil (petroleum), natural gas, and coal price indices. Figure 1 gives the evolution of these commodity prices.

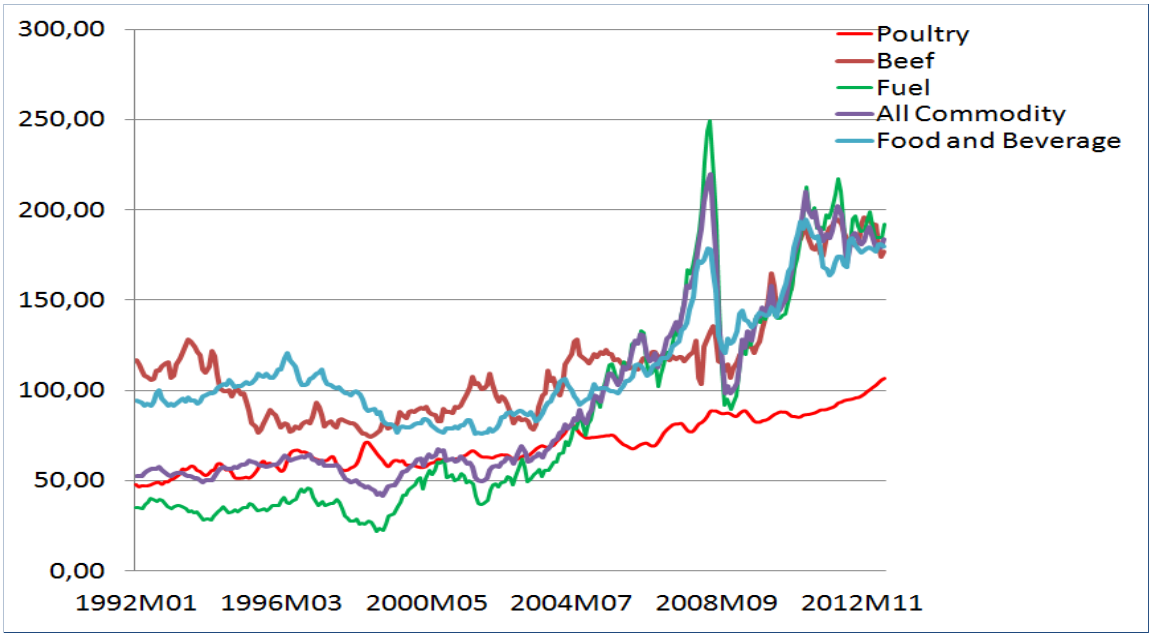

Figure 1. Evolution of Poultry and Some Commodity Prices from January 1992 – July 2013.

Notes. Author's construction based on IMF commodity price data. The figure shows that poultry prices are relatively more stable when compared to other commodity prices.

A rapid look at Figure 1 shows that commodity prices have experienced much more volatility in recent years and reveals the price upsurges of 2007-2008 and 2010-2011. However, poultry prices have shown to express less volatility than other commodity prices and didn't show a clear pick during the 2007-2008 and 2010-2011 periods. This conjecture can be better analyzed in an econometric model of volatility transmission.

Modeling Volatility Transmission

In order to get an answer to the above-mentioned question, this paper uses the econometric approach to the empirical analysis of the volatility of international commodity prices. To analyze the propagation of volatility between poultry and other commodities, the paper uses two complementary approaches: the GARCH and the vector autoregressive frameworks.

Firstly, we use the above-described GARCH model where we add the volatility of other commodity prices as explanatory variable in the variance equation of the first difference of logarithmic poultry prices. In fact, a GARCH model consists of a mean equation and a conditional variance equation. This basic specification can be extended by adding exogenous or predetermined variables both in the mean equation and in the conditional variance equation. Therefore, in our empirical exercise, we include the conditional standard deviation of other commodity prices in the mean equation of the log difference of poultry prices to get the

GARCH-in-Mean or GARCH-M model (Engle, Lilien, and Robins 1987). We also include this conditional standard deviation of other commodity prices in the conditional variance equation of the log difference of poultry prices to get the effect of uncertainty in one agribusiness sector, or in one commodity market, on the volatility of poultry prices.

By adding the conditional standard deviation in the mean equation of the log difference of poultry prices, the model analyzes the effect of the expected risk in one agribusiness sector on the expected return of the poultry sector and can assess the risk-return tradeoff. Also, by adding the conditional standard deviation in the variance equation of the log difference of poultry prices, the model can assess the possibility of the transmission of volatility from one agribusiness sector, or from one commodity market, to the poultry sector.

Secondly, we use the VAR framework to derive impulse response functions of poultry price volatility to shocks affecting selected commodity prices' volatility.

Empirical Findings

The Relative Stability of Poultry Prices

Following the evidence provided by many authors (Engle et al. 1993; Lamoureux and Lastrapes 1993; West et al. 1993) in support of the GARCH (1, 1) among other specifications, we use this first order for ARCH and GARCH terms in the econometric model. We compute conditional variance from the estimated variance equation and we take its square root as the measure of price volatility. Figure 2, Figure 3 and Figure 4 give these figures graphically. Figure 2 plots in a single graph the volatility dynamics of all commodities under consideration while Figure 3 removes non-agricultural prices in order to have only the volatility of poultry and that of its substitutes (beef, fish, food and beverage). Figure 4 plots these volatility dynamics in multiple graphs.

Both Figure 2 and Figure 3 show an increased volatility in my selected commodity prices during the 2007-2008 and 2010-2011 periods. The volatility peaks have been more pronounced for beef prices followed by the aggregated index of food prices. Fish meal prices exhibit a more complicated volatility dynamics. However, poultry price volatility has shown a different dynamics. A closer inspection of Figure 3 reveals that poultry sector has registered less volatility that other commodities under consideration and didn't clearly show an increased volatility during the 2007-2008 and 2010-2011 global instability periods. This result is better visible in multiple graphs.

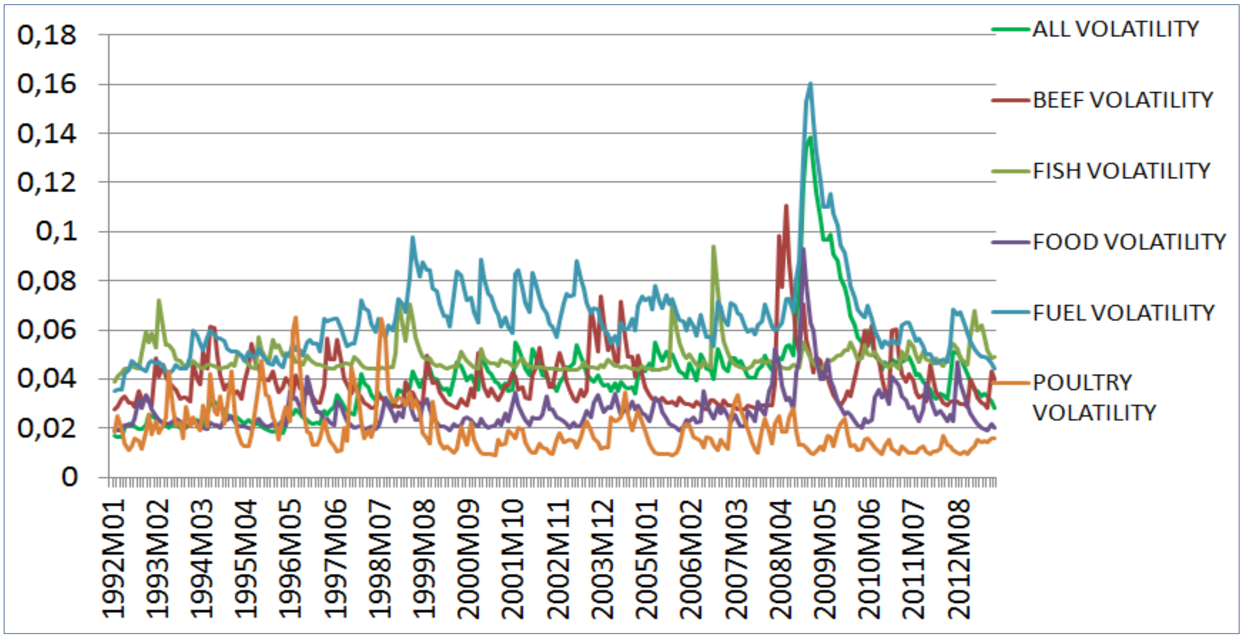

Figure 2. The Dynamics of Poultry and Other Commodity Prices' Volatility.

Notes. All volatility= standard deviation of log difference of all commodity price index; Beef volatility= standard deviation of log difference of beef prices; Fish volatility= standard deviation of log difference of fish meal prices; Food volatility= standard deviation of log difference of food price index; Fuel volatility= standard deviation of log difference of energy prices; Poultry volatility= standard deviation of log difference of poultry prices.

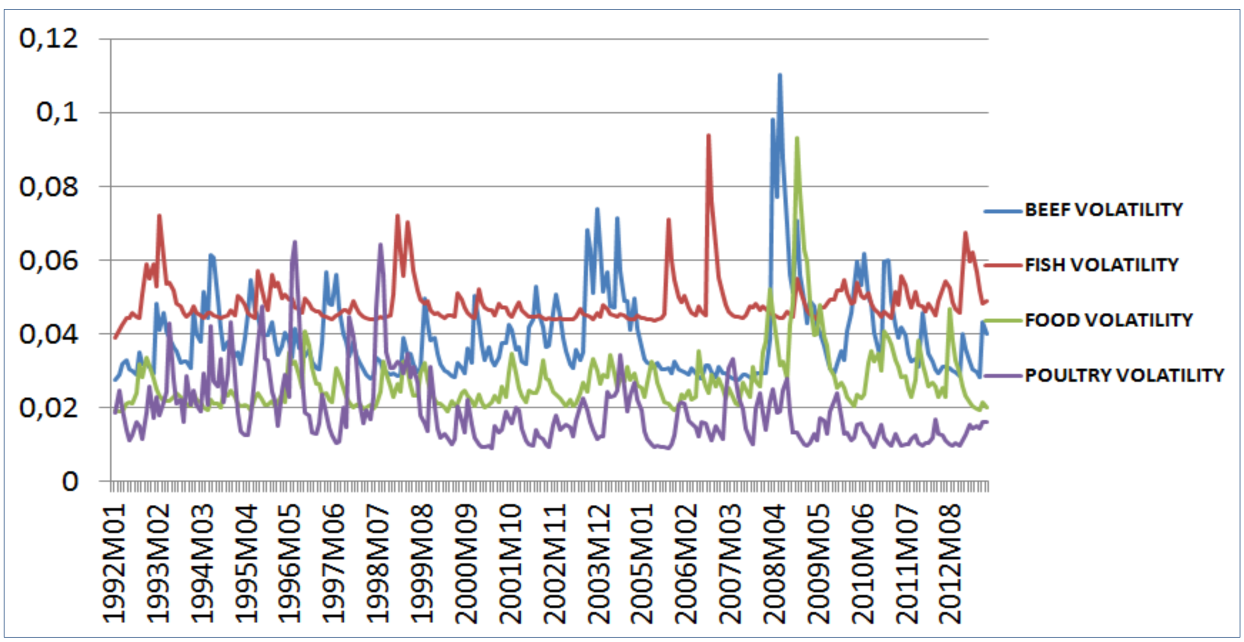

Figure 3. The Dynamics of Poultry and Other Commodity Prices' Volatility (Without non-agricultural prices).

Notes. BEEF VOLATILITY= standard deviation of log difference of beef prices; FISH VOLATILITY= standard deviation of log difference of fish meal prices; FOOD VOLATILITY= standard deviation of log difference of food price index; POULTRY VOLATILITY= standard deviation of log difference of poultry prices.

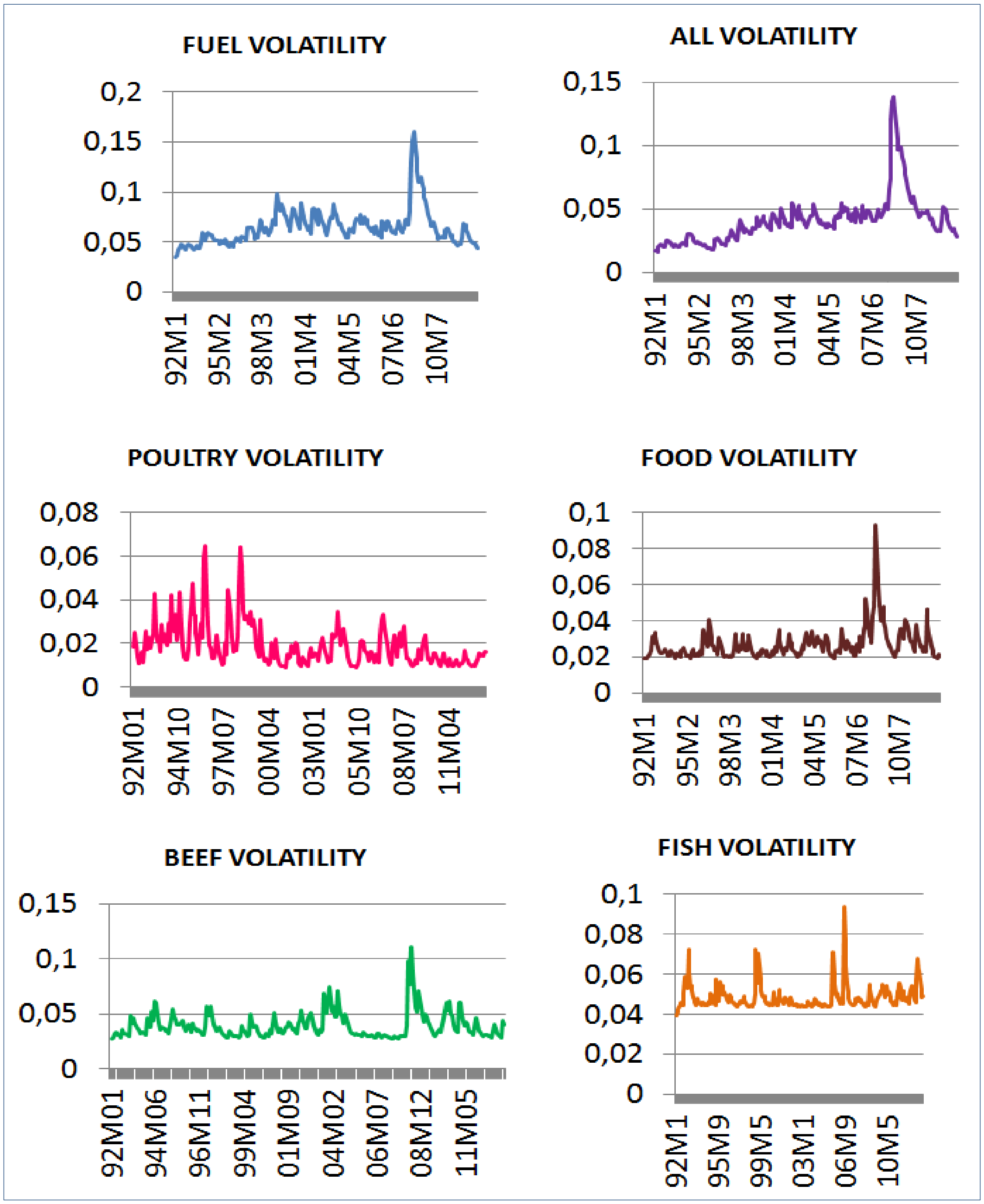

Figure 4. The Dynamics of Poultry and Other Commodity Prices' Volatility.

Notes. Fuel volatility= standard deviation of log difference of energy prices; All volatility = standard deviation of log difference of all commodity price index; Poultry volatility = standard deviation of log difference of poultry prices; Food volatility = standard deviation of log difference of food price index; Beef volatility = standard deviation of log difference of beef prices; Fish volatility = standard deviation of log difference of fish meal prices.

Figure 4 shows the same results as previously: poultry prices have experienced less volatility comparatively to other commodities under consideration and poultry price volatility didn't show a clear increase during the recent global instability episodes.

These results are confirmed by the summary statistics of commodity prices' volatility. Table 1 presents summary statistics of the volatility measure (conditional standard deviation of log difference) of poultry prices and that of other commodities under consideration.

Table 1. Poultry and Other Commodities' Price Volatility.

	SDALL[a]	**SDBEEF[b]**	**SDFISH[c]**	**SDFOODPI[d]**	**SDFUEL[e]**	**SDPOULTRY[f]**
Mean	0.0407	0.0391	0.0480	0.0283	0.0480	0.0190
Median	0.0388	0.0356	0.0484	0.0256	0.0484	0.0159
Maximum	0.1382	0.1110	0.0617	0.0919	0.0617	0.0652
Minimum	0.0162	0.0275	0.0280	0.0198	0.0280	0.0091
Standard dev.	0.0190	0.0119	0.0051	0.0084	0.0051	0.0096
Sum[g]	10.482	10.056	12.354	7.2733	12.354	4.8831
Observations	257	257	257	257	257	257

Notes. Descriptive statistics obtained from the computation of the standard derivations of selected commodity prices. Standard deviation is computed as the square root of the conditional variance fitted from the variance equation in the GARCH (1, 1) model of log difference of commodity prices. Results show that the poultry price volatility has the lowest mean and median. a= standard deviation of log difference of all commodity price index; b= standard deviation of log difference of beef prices; c= standard deviation of log difference of fish meal prices; d= standard deviation of log difference of food price index; e= standard deviation of log difference of energy prices; f= standard deviation of log difference of poultry prices; g=Sum of the concerned commodity price volatility over the period from January 2012 to June 2013.

Table 1 gives the same results as Figures 2, 3 and 4. Poultry price volatility has the lowest median, the lowest mean, and the lowest sum. Even its standard deviation is among the lowest; just slightly greater than that of fish and that of fuel price volatilities. Therefore, poultry prices have experienced less volatility than other commodities.

All in all, it appears that poultry sector has shown to be resistant to the recent global commodity price instability. This could mean that the transmission of volatility and uncertainty from other commodities to poultry sector is rather weak.

The Resistance of Poultry Prices to Variance Spillovers

To analyze the transmission of volatility from other commodities to poultry sector, we once again use the GARCH (1, 1) model of log difference of poultry prices where we add the conditional standard deviation of other commodities as explanatory variable. Results are shown in Table 2.

Table 2 shows that the coefficient of all commodity prices' volatility and the coefficient of beef prices' volatility are insignificant in the variance equation of poultry prices. Therefore, the volatility of other commodity prices didn't statistically explain the volatility of poultry prices. This result means that there is not a transmission of volatility from other commodities to poultry sector or in other words, shocks in other commodities can't contaminate poultry. Therefore, we can state that "Mastitis can't contaminate poultry"[1] not just because poultry didn't produce milk but, and it is what this paper shows, because price volatility and uncertainty didn't transmit from other commodities to the poultry sector.

Table 2. Variance Equation of Log Difference of Poultry Prices.

Variable	SD ALL[a]		SD BEEF[b]		SD FISH[c]		SD FOOD[d]		SD FUEL[e]	
Constant	7.54^{E-6}		7.51^{E-6}		0.0002		9.77^{E-5}		0.0002	
	(0.926)		(0.47)		(16.03)	***	(2.81)		(16.1)	***
$[RESID(-1)]^2$	0.173		0.168		0.156		0.477		0.156	
	(3.411)	***	(3.69)	***	(3.44)	***	(3.15)	***	(3.44)	***
GARCH(-1)	0.826		0.835		0.837		0.434		0.837	
	(23.05)	***	(26.97)	***	(25.26)	***	(3.89)	***	(25.3)	***
Other price volatility	-0.7^{E}-5		-0.0001		-0.005	***	-0.002		-0.005	
	(-0.63)		(-0.301)		(-13.6)		(2.38)	**	(13.6)	***
R^2	0.0190		0.012		0.0051		0.010		0.0052	
Observations	257		257		257		257		257	

Notes. Variance equation estimates from the GARCH (1, 1) model of log difference of poultry prices. Z statistics in parenthesis. *,**,*** denote significance at 10%, 5% and 1% respectively. The all commodity and beef prices' volatilities didn't affect poultry price volatility. Fish, fuel and food prices' volatilities have shown up with significant coefficients in poultry price volatility equation; but these results are rather weak as regard, for instance, the R2 s. a= standard deviation of log difference of all commodity price index; b= standard deviation of log difference of beef prices; c= standard deviation of log difference of fish meal prices; d= standard deviation of log difference of food price index; e= standard deviation of log difference of energy prices.

To further investigate the resistance of poultry prices to variance spillovers, we derive impulse response functions from a Vector Autoregression (VAR) model of commodities' price volatility. These impulse response functions trace the effect of a one-time shock to the innovation of the volatility of one of the commodities under consideration on current and future values of the poultry price volatility. In this sense, they help to analyze the "volatility of volatility" following a tradition in the recent literature on time variation in volatility (Weber 2013; Corsi at al. 2008). Figure 5 gives, graphically, these impulse response functions.

[1] This assertion didn't mean that we have undertaken the analysis of the causal relationship between the Diary sector (or more specifically between the appearance of Mastitis) and poultry prices but rather, it is meant to put forth the idea of the resistance of poultry prices to global instability where even such "paradoxical" contamination could exist.

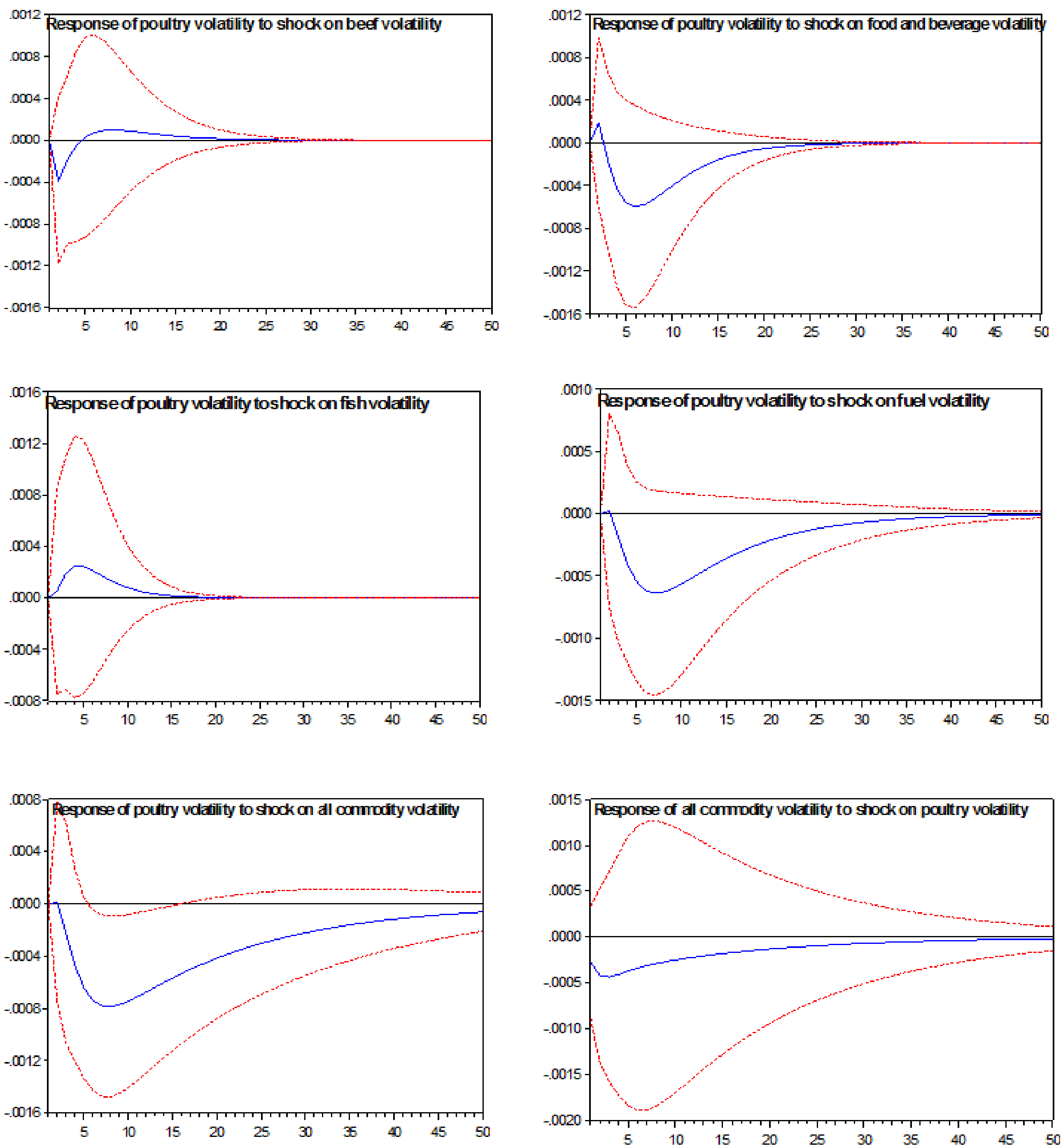

Figure 5. Impulse Response Functions of Poultry Price Volatility to Other Commodities' Volatility.

Notes. Response to Cholesky one standard deviation innovations (plus and minus two standard deviations)

These impulse response functions tend to confirm our previous findings. Shocks to other commodities' price volatility have very brief effects on poultry price volatility. For instance, a shock on the fish price volatility has very negligible effects that die out in less than fifteen months. Moreover, shocks on the all commodity price index's volatility reduce poultry price volatility up to fifty months later. Likewise, shocks on food and beverage price index's volatility increase volatility of poultry prices for less than five months then, negatively affects it up to twenty months. Shocks on beef price volatility reduce poultry price volatility for two to five months and later exert very negligible positive effects that die out in less than twenty months. Given the above findings, we can conclude that poultry prices have been resistant to the 2007-2008 and 2010-2011 global instability.

Implications

Policy Implications

As poultry seems less vulnerable to external volatility, policies aiming to promote poultry production and trade should concentrate on preventing and managing its intrinsic volatility. Efforts should mainly be oriented towards the management of this sector's idiosyncratic shocks such as the appearance of diseases (avian influenza or Newcastle's disease) or the recall of poultry derived products.

Although the volatility transmission is generally related to market activity variables such as the volume of trade, the flow of orders or the arrival of new information (Weber 2013), its consequences go far beyond financial difficulties. In fact, the contaminated sector, by facing excessive volatility, could fail to realize its production potential because of reduced investment both at the primary production level and at the processing level (Buckley 2012).Yet, underinvestment in agriculture is one of the main explanations given to the 2007-2008 and 2010-2011 price spikes (World Bank 2007). This could lead to more instability in the commodity markets and to more price volatility. Therefore, commodity price stabilization programs such as producer subsidies, buffer stock programs and price supports are implemented in reaction to high price volatility. However, developing countries can't efficiently implement these programs because they involve sizeable amounts of resources. As poultry is relatively resistant to external volatility, such countries should specialize in this sector.

Some authors such as Sarris (2000) have suggested the use of international hedge funds in the management of risk inherent in the volatility of commodity prices. Such interventions must therefore consider poultry as a relatively safe asset in the composition of the portfolio.

Lessons for Risk Management in Agribusiness: Is Poultry a Safe Asset?

Speculative influences have been emphasized by Cooke and Robles (2009) or Gilbert (2010) as one of the main explanations given to the 2007-2008 and 2010-2011 price spikes. The modeling of volatility transmission helps to analyze the risk of holding an asset or the value of an option. Understanding the transmission of volatility processes between poultry and other commodities could therefore help to design better risk management tools in agribusiness. In fact, as the empirical results show that poultry prices are resistant to volatility spillovers from other commodity prices, poultry could be considered as a relatively safe asset when building a portfolio. At the production level, actors of agribusiness can diversify their activities by including poultry as a 'safe' component of their business (at least from financial point of view).

However, this does not mean that poultry is a totally safe activity. As any other business, this sector has its own risk and uncertainty (the risk of appearance of diseases such as avian influenza or Newcastle's disease for instance). What our empirical results mean is that, from the financial point of view, poultry could not be contaminated by other commodities' uncertainty.

Conclusions

Price volatility is welfare decreasing and harmful both for the production and commercialization of agricultural products (Zheng et al. 2008). This paper analyzes the volatility transmission from some selected commodity prices to poultry prices. Using the conditional standard deviation of the log difference of prices as the measure of volatility and a GARCH (1, 1) model to compute this volatility, we obtain the following results: poultry prices experienced less volatility in recent years relatively to other commodity prices; the transmission of price volatility from other commodities to poultry prices is rather weak. These results could help to design better risk management tools in agribusiness. In particular, actors of agribusiness could consider poultry as a relatively safe activity when they choose their portfolio of activities. Moreover, as poultry prices have shown to be less sensitive to other commodities' uncertainty, policy intervention should concentrate on managing this sector's idiosyncratic shocks such as the avian influenza or Newcastle's disease.

Acknowledgements

I would like to express my gratitude to two anonymous referees and to the Managing Editor of this special issue for providing helpful comments and suggestions. As usual, all errors are mine.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

The Poultry Market in Nigeria: Market Structures and Potential for Investment in the Market

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Abstract

High population growth and growing income lead to increasing demand for poultry products in Nigeria. The poultry industry has emerged as the most commercialized and fastest expanding segment in the animal husbandry subsector but still faces many problems. Private investment from foreign countries could help to facilitate this market. This paper reveals the opportunities and threats of a market entry for private investors based on a PESTEL analysis and a SWOT analysis.

Keywords: market potential, Nigeria, PESTEL analysis, poultry production, SWOT analysis

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Introduction

In 2013, six of the ten fastest growing economies in the world were in Africa. With an average annual growth in gross domestic product (GDP) of 5% in recent years, this situation is likely to continue (International Monetary Fund 2014). In Africa, agriculture and agro-industries account for more than 30% of national incomes on average, as well as for the bulk of export revenues. Nearly three-quarters of the African population depend on agriculture to secure their livelihoods (Oram 2012; Connolly 2014).

Due to the high population growth in Africa (World Health Organization 2010) and growing income, the demand for eggs and poultry meat has significantly increased in recent years across large parts of the continent. According to estimates by the USAID (United States Agency for International Development), this trend is very likely to continue over the next few years. Therefore, the consumption of poultry and eggs will increase by 200% between 2010 and 2020 for at least some countries in sub-Saharan Africa (Obi 2003; USDA 2013).

One African country where this trend can clearly be seen is Nigeria. Nigeria is one of the largest countries in Africa, with a total geographical area of 923,768 square kilometers (Manyong et al. 2005). Its estimated population was 174.5 million people in 2013, and its population growth rate is 3% per annum (USDA 2013). Nigerian economic statistics reveal annual economic growth rates that averaged over 7% in recent decades, making Nigeria one of the fastest growing economies in the world (Byerlee et al. 2013). Nonetheless, this growth has not reduced poverty or created much-needed jobs. Unemployment is still very high, and more than 60% of the population lives below the poverty line (African Economic Outlook 2012).

In contrast to the rapid population growth in Nigeria, food production has not followed suit over the last 50 years (Wiggins and Keats 2013). Nevertheless, the sector is particularly important in that it has generated employment and contributed to GDP and export revenue earnings. Hence, agriculture constitutes one of the most important subsectors of the economy, employing nearly three quarters of Nigeria's work force (Phillip et al. 2009; Adene and Oguntade 2006).

The Nigerian poultry industry in particular has been rapidly expanding in recent years and is therefore one of the most commercialized (capitalized) subsectors of Nigerian agriculture (USDA 2013; Adene and Oguntade 2006). The popularity of poultry production can be explained by the fact that poultry has many advantages over other livestock. Poultry birds are good converters of feed into useable protein in meat and eggs. The production costs per unit remain relatively low, and the return on investment is high. Therefore, farmers need a relatively small amount of capital to start a poultry farm. Furthermore, poultry meat is very tender and acceptability to consumers is high, regardless of their religious beliefs. Also, the production cycle is quite short, so capital is not tied up over a long period. Finally, eggs, one of the major products of poultry production, are more affordable for the common person than other sources of animal protein (Ojo 2003; Aboki et al. 2013).

Despite these positive aspects, poultry production has not been keeping pace with rapidly increasing domestic consumption. The domestic shortfall is estimated at 25,000 MT per annum (Rothschild 2002).

This lagging increase in domestic production can be explained by the fact that most producers in Nigeria still employ traditional rural poultry farming systems—although an increasing demand for poultry kept under modern and more hygienic conditions has been observed. Rural poultry farming is by convention a subsistence system comprising stocks of nonstandard breeds or mixed strains, types, and ages. A majority of the farmers operate in these traditional, small-scale structures. Often, these farming systems are characterized by outdated barn equipment and production techniques and inadequate hygiene management. In addition, producers suffer from a weak feed industry and poor market access as a result of inadequate infrastructure (Adene and Oguntade 2006; Alabi and Isah 2002).

In contrast, commercial poultry farming is characterized by higher demands on capital and labor, as well as on inputs and technology. Improvements in breeding, husbandry, and management are needed to increase the efficiency in chicken production, which will lead to lower production costs (Adene and Oguntade2006).

But even farmers using more commercial farming systems suffer from numerous problems. These problems include a low capital base, the resulting lack of equity capital, inefficient management, technical and economic inefficiencies, infection with diseases and parasites, high costs for feeds, poor quality of day-old chicks, and inadequate extension and training facilities (Alabi and Isah 2002; Bambgbose et al. 1998). Thus, there seems to be a large untapped potential for improvements in poultry production in Nigeria from both a production and an economic point of view.

To the best of our knowledge, there is hardly any literature so far that examines the existing market structures of poultry production in Nigeria, analyzes the potential of emerging new markets, and segments or explores the development of suitable strategies for the market entry of companies from foreign countries. Therefore, it is the aim of the present paper to contribute to the closing of this research gap. To this end, we describe Nigeria’s economic development in detail, taking into account general economic indicators and the relative importance of animal husbandry. We pay special attention to the development of the poultry sector, analyzing in depth the market in laying hens and egg production, as well as the subsector of broiler production.

To analyze the environment and current state of the poultry market in Nigeria, we conducted a PESTEL (political, economic, social-cultural, technological, ecological, legal) analysis and a SWOT (strengths, weaknesses, opportunities, threats) analysis. Then, based on the SWOT analysis, we investigated the attractiveness of market entry from the perspective of a foreign direct investor.

Background

Foreign Direct Investment in Emerging Markets in Sub-Saharan Africa: The Example of Nigeria

In no other region is the potential for poverty reduction through the agricultural sector greater than in sub-Saharan Africa (Larsen et al. 2009), where 70% of the people live in rural areas and 90% of the rural population depends on agriculture as the main source of income (United Nations Economic Commission for Africa 2007). With the help of investments from sources around the globe, agribusiness began booming in the early 2000s, and it is projected to become a US $1 trillion industry in the region by 2030 (Byerlee et al. 2013).

However, in comparison to other parts of the world, productivity levels in sub-Saharan African agriculture and industry are still extremely low, and consequently agribusiness development cannot keep pace with the rapidly growing population and increasing incomes. As a result, food imports have grown since the 1970s, and sub-Saharan Africa has become a net food importer (World Bank 2007a). In Nigeria, wheat is the largest single import. To safeguard local production, some import prohibitions have recently been passed. For instance, to protect the Nigerian poultry sector there is a total ban on importing poultry, whether dead or alive (Nicely 2013).

To establish sustainable agriculture, higher agricultural productivity plays a key role for growth and development in most African countries (Larsen et al. 2009). Even though there is plenty of room to increase the productivity and the technical and economic efficiency of Nigerian poultry producers, poultry production is already highly profitable for Nigerian farmers (Aboki 2013; Ohajianya et al. 2013). This gives cause to hope that even more farmers can improve their financial situation through poultry farming.

Innovation is a powerful means of addressing relatively low production and added value. Therefore, understanding how innovation takes place and developing policies and institutions that facilitate enhanced innovation are central to the progress of agricultural development in Africa (World Bank 2007b). Innovation in agribusiness provides the new inputs, expertise, and services needed for farm production; at the same time, it offers markets for farm products. Thus, it expands employment and entrepreneurial opportunities in rural and urban areas and can contribute to the growth of micro- and small enterprises (OECD 2007).

Despite these potential benefits, the level of innovation adoption among poultry producers in Nigeria is still quite low (Ladele 2002). Aboki et al. (2013) show that the index of innovation adoption has a negative relationship with the inefficiency of family poultry production in parts of Nigeria. Innovations triggered by policies and private companies can therefore enhance the level of efficiency and improve the situation of poultry farmers.

Due to the liberalization of economies and the globalization of trade, the growth and development of agribusiness depend largely on international private sector initiatives or public policies (Larsen et al. 2009). The Nigerian government has therefore decided to liberalize competitive international trade (FAO 2014) in order to support the export of agricultural goods.

For Nigerian poultry producers, however, exports play only a minor role since poultry production is intended to meet the needs of the local population (Encyclopedia of the Nations 2014).

In this paper, we focus on private sector initiatives, as many transnational agribusiness companies have become involved in a number of aspects of food production in sub-Saharan Africa, including the agricultural input sector, farming, the food processing industry and the transportation and distribution of food (Dinham and Hines 1984). Meanwhile, soaring grain prices and global food inflation have strengthened investor interest in African agriculture, especially because Africa has the land availability and space for farm production to grow significantly (World Bank 2007b).

In recent years, many of the continent's governments have changed to more market-friendly policies and are committing more resources to the agricultural sector. Therefore, African agriculture's private sector investment is rising rapidly. African agriculture attracted more than US $100 million in private equity investment in the first half of 2012, compared to US $50 million for the whole of 2011 (e.g., foreign investments in feed, modern breeds, husbandry systems, management techniques) (World Bank 2007b). Nevertheless, introducing cost-effective agricultural development in the countries of sub-Saharan Africa is still a challenge. To succeed, companies that are willing to enter the African market will have to address numerous technical hurdles, such as limited availability of human resources, corruption, political pressures, shifting priorities, and inadequate infrastructure and market access (Sanghvi and Simons 2014).

Importance of Poultry Products in Sub-Saharan Africa

The challenges of food insecurity and hunger in developing African countries like Nigeria have caught the attention of experts and governments worldwide (Emaikwu et al. 2011; FAO 2003). Population growth, urbanization, and income improvements are the main drivers of increased demand for foods of animal origin in developing countries (Abdullah et al. 2011; Steinfeld 2003). The sufficient supply of animal protein is most critical in the global food basket crisis (FAO 1995). As a result, growing demand has led to a rise in the production of foods of animal origin all around the globe, especially from poultry and pigs (FAO 2010).

Poultry production plays an important role in rural incomes in sub-Saharan Africa; especially in Nigeria (Mengesha 2011; Van der Sluis 2007). A country's economic development is normally accompanied by improvement in its food supply and the gradual elimination of dietary deficiencies (WHO/FAO 2003; Thornton 2010). This raises global demand for animal products, thus offering potential opportunities for animal producers worldwide (Jabbar et al. 2011). The enforced demand for foods of animal origin could be satisfied especially by the production of poultry, as these products have seen the greatest increase in production in recent years (FAO 2011; Speedy 2003; Delgado and Narrod 2002).

For farmers in sub-Saharan Africa, poultry production plays an exceptionally important role; approximately 80% of rural households are engaged in smallholder poultry production (Kryger et al. 2010). But, although chicken production is likely to become the fastest growing agribusiness sector in sub-Saharan Africa, it still faces problems of feed-food competition and dependency on the import of improved breeds (Aboul-Naga and Elbeltagy 2007).

In Nigeria, where the production of animal protein falls far short of meeting the demands of a rapidly growing population (Obi 2003), poultry is the most common livestock kept (Armar-Klemesu and Maxwell 2000). The poultry industry has emerged as the most dynamic and fastest growing segment in the animal husbandry subsector. It represents an important source of high quality proteins, minerals, and vitamins to balance the human diet (USDA 1999).

Methods

The results of this study are based upon a comprehensive analysis of the available national and international literature. As part of this research, it became apparent that the literature on this topic is very limited.

In our study we applied a stepwise approach. We began with a PESTEL analysis to identify the political, economic, social-cultural, technological, ecological and legal factors that could influence the market entry decisions of agribusiness companies from foreign countries. A PESTEL analysis is a strategic tool organizations can use when planning to launch a new product or service, explore a new route to market, or start selling to a new country or region. (Team FME 2013; Zingel 2009). PESTEL analysis is therefore a strategy for analyzing the attractiveness of markets and restricting the external risks of investment (Gassner 2009; Johnson et al. 2011). Every investment decision has its own PESTEL analysis depending on the relevant potential market. Table 1 lists the most important external factors that might influence a company's investment in poultry production in Nigeria.

Next, we conducted a SWOT analysis to investigate the strengths and weaknesses, as well as the opportunities and threats of an investment. SWOT analysis was introduced in the 1960s as a tool for supporting companies' strategy identification process (Weihrich 1982). With regard to the internationalization of business activities, this leads to market-entry strategies adapted to specific situations in different markets. Thus, SWOT analysis is a strategic management tool suitable for a detailed analysis of the environment in order to utilize existing market opportunities (Dyson 2004).

Since every company confronts a dynamic environment, the relative importance of strategic factors can be dynamically adapted; thus, a SWOT analysis is not permanent in nature (Houben et al. 1999). It usually investigates a company's internal strengths and weaknesses as well as the opportunities and threats of its external environment (Hill and Westbrook 1997). This paper uses a modified version of the SWOT analysis to determine the current strengths and weaknesses of the Nigerian poultry sector and to predict the future opportunities and risks of market entry. Therefore, all the criteria are external factors that are relevant for companies considering an investment in this market.

Based on the catalogue of PESTEL criteria listed in Table 1, we set up a SWOT matrix for the Nigerian poultry market, making its strengths, weaknesses, opportunities, and threats clearly visible. Specific potential for market entry can be derived through this study.

Table 1. Factors used in the PESTEL Analysis of the Nigerian Poultry Market

Political	Agricultural policy	Corruption
	Availability of micro-credits for farmers	Governmental structure
		Governmental stability
Economic	Capital base of farmers	Inflation
	Economic efficiency of production	Infrastructure
	Economic growth	Input costs
	Gross domestic product	Market price fluctuation
	Importance of agricultural sector	Marketing possibilities
	Income per capita	Profitability
Social-cultural	Age structure	Household size
	Availability of labor	Innovation adoption
	Education level	Management practice and know-how
	Employment rate	Membership in co-operative
	Extension and training agency	Population growth rate
	Farming experience	Poverty
	Health	Religious influences
Technological	Diseases and parasites	Level of automation
	Drugs and medication	Mortality rate of chickens
	Farm size	Quality of day-old chicks
	Flock size	Storage facilities
	Husbandry systems	Technical efficiency of production
	Hygienic conditions of poultry production	Use of modern breeds
		Vaccination
Ecological	Availability of Land	Availability of water
	Availability of energy	Climatic conditions
	Availability/Quality of feed	
Legal	Export regulations	Taxation regulations
	Import regulations	

Sources. Adapted from Gassner 2009; Johnson et al. 2011; Aboki et al. 2013; Esiobu et al. 2014; Ohayianya et al. 2013; Ojo 2003; Udoh and Etim 2009; Nmadu et al. 2014; Tijjani et al. 2012.

Results

Results of the PESTEL Analysis

Political Factors

Nigeria has a federal structure, with 36 states and a federal capital territory. Each of the states has its own political administration with a governor at the top. Even though Nigeria claims to be a federal republic, the central government in Abuja holds the majority of the political power, especially because it has exclusive rights to the country's oil revenues. Moreover, the president is enormously powerful because, in addition to his executive role, he also enjoys additional legislative powers (Agbaje 2004). Despite improvements over the last few years, Nigeria still ranks poorly in regard to corruption—placing 136 of 175 countries surveyed according to Transparency International-the global coalition against corruption (Transparency International 2014).

Large parts of the population are still very poor due to corruption, even though large oil reserves and the great variety of landscape and biodiversity offer enormous income generation opportunities for the urban population (Falola and Heaton 2008; Bergstresser 2010; Bach 2006). The political system in Nigeria seems to be relatively stable, as noteworthy political and economic reforms have been implemented. At the same time, the government does not effectively react to the threats of terrorism and the violent ethno-religious conflicts that have torn the country apart in recent years. Of course, there have been costly attempts to increase security. But because of the high corruption rate among high-level politicians, security officers, ex-military, and businesspeople, these efforts have triggered hardly any improvement (Bergstresser 2014).

Nevertheless, the more recent development of agricultural policies shows that there is a strong will to facilitate agricultural marketing, reduce agricultural production costs, and enhance agricultural product prices as incentives for increased agricultural production. The instruments used for this purpose include agricultural commodity marketing and pricing, input supply and distribution, input price subsidy, land resource use, agricultural research, agricultural extension and technology transfer, agricultural mechanization, agricultural cooperatives, and agricultural water resource and irrigation development (Manyong et al. 2005). Furthermore, several incentives have been implemented to encourage investment in the Nigerian agricultural sector:

- A zero duty on agricultural machinery
- Pioneer status incentive (three years tax holiday) for the agro-processing industry
- Export incentives available for manufactures in the agrarian sector
- Food import prohibitions to encourage local production (Nigerian Investment Promotion Commission 2014)

Poultry production in Nigeria is still characterized by low production levels due to the limited financing available for the procurement of basic equipment and materials. Many farmers are unable to increase their productivity by moving from small-scale poultry production to larger-scale production because they face difficulties in credit and loan procurement. To enhance the commercialization of the poultry industry, it has been suggested that Nigerian government policy tackle the problem of credit procurement through expanding the provision of micro-credits and encouraging the formation of cooperative societies for farmers (Akanni 2007; Aromolaran Adetayo et al. 2013; Aboki et al. 2013; Esiobu 2014). In fact, there are already a few programs that seek to give farmers access to micro-credits (Aboki et al. 2013), representing a positive starting point.

Economic Factors

Nigeria’s economy is characterized by strong economic growth (The World Bank 2014b).

Nonetheless, about two thirds of the population lives on less than US $1 per day. This indicates that economic growth has not cut poverty or created necessary jobs. The inflation rate is comparatively high, but fell from 13.7% in 2010 to at least 8.4% in 2013 (African Economic Outlook 2012).

Despite the oil boom, agriculture is still the major sector in the Nigerian economy (Oji-Okoro 2011). Agriculture accounts for 35.2% of GDP and must therefore play a key role in unleashing inclusive economic growth, reducing poverty, and enhancing food security (African Economic Outlook 2012).

The agricultural sector is an important employer for the rural population, employing about 70% of the active labor force (Adene and Oguntade 2006).

Nigeria has a relatively advanced infrastructure, compared to many other African countries. Roads still lag far behind, but airports and ports have enjoyed considerable investment in recent years, resulting in good international portals. The government has also increasingly advocated the use of public–private partnerships; therefore, infrastructure networks cover extensive areas of the national territory. It is estimated that improving the country’s infrastructure still further could boost annual real GDP growth by around four percentage points (PwC 2014).

Ohajianya et al. (2013) examined the economic efficiency of poultry production in parts of Nigeria. Their results show that, from an economic perspective, many producers manage their poultry farms inefficiently and therefore lose highly promising cost savings. As economic efficiency is a product of technical and allocative efficiencies, these factors should be improved to make poultry production even more profitable in the future. To be technologically effective, farmers need to invest in production factors. Inadequate funding hinders farmers from acquiring the necessary resources and technologies to assist them to produce efficiently and remain in production (Esiobu et al. 2014).

The costs of medication and vaccination and of feed constitute substantial input costs in production (Esiobu et al. 2014). A number of studies have shown that feed costs constitute one the highest variable costs in the poultry production process (Esiobu et al. 2014; Nmadu et al. 2014; Ohajianya et al. 2013; Tijjani et al. 2012). Moreover, in recent years, there has been a rapid increase in the price of feed. This constraint makes it difficult for farmers to purchase the quantity of feeds needed for efficient poultry production. Up to now, no solution has been found for this problem, which continues to hinder the growth of productivity in poultry production.

Another important economic factor is the fluctuating market prices for poultry products in Nigeria. The price for poultry meat and eggs does not vary proportionately with the rising feed prices and other costs confronting producers. This generates considerable uncertainty for poultry producers (Murtala 2004).

In addition, many small-scale farmers suffer from marketing problems since they do not always have market access. Poor infrastructure leaves farmers unable to reach out to market outlets. Therefore, they can only resort to farm gate sales, which reduces their marketing efficiency and marketing margin. The establishment of agricultural co-operative groups could help them achieve better market access and obtain credit from government and other financial institutions (Esiobu et al. 2014; Tijjani et al. 2012).

Social-Cultural Factors

Nigeria is the most populous country in sub-Saharan Africa. About two thirds of the population lives on less than US $1 per day, and the unemployment rate in 2011 was approximately 24% (African Economic Outlook 2012).

Ohajianya et al. (2013) showed that poultry production is heavily influenced by the cost of hiring labor and the availability of well-qualified labor. Labor costs are among the major cost factors of poultry production and, due to low education levels, qualified labor is comparatively rare (Ohajianya et al. 2013). However, not every farmer is dependent on hired labor. If a family is large enough, labor requirements for can be met by family members, which reduces the extra cost of hiring labor (Emaikwu et al. 2011). Household size therefore exerts considerable influence on the profitability of poultry production (Emaikwu et al. 2011; Esiobu et al. 2014).

The government has been implementing education reforms since 2006 to improve access to education, increasing the literacy rate for the 15-to-24 age group by about 15% between 2000 and 2008 alone. Nonetheless, education quality is generally low and varies considerably across the country. In 2010, only 25% of the Nigerian population had completed elementary schooling in English, mathematics, and at least three other subjects (African Economic Outlook 2012). Since illiteracy has been shown to be a major limitation to technology adoption in livestock and crop production, increasing the overall educational level would enable farmers to access relevant information that will stimulate their production (Aboki et al. 2013; Esiobu et al. 2014; Onubuogu et al. 2013; Onubuogu et al. 2014).

The average age in Nigeria is 19.1 years, and life expectancy at birth is about 53 (World Health Organization 2014). Onyebinama (2004) and Esiobu et al. (2014) found that farmers with more years of farming experience are more efficient, have better knowledge of climatic conditions and the market situation, and are therefore able to run their enterprises more profitably. Thus, the success of poultry production is significantly influenced by age and farming experience (Aboki et al. 2013).

Despite this, health and education indicators in Nigeria remain weak; the country ranked 156 out of 187 countries in the UN Human Development Report in 2010. Improvement with regard to social welfare indicators has been much slower than might be expected, given the country's economic growth. Nevertheless, social conditions such as education have shown continual improvement in recent years (Byerlee et al. 2013).

Nigeria is composed of more than 250 ethnic groups. Furthermore, the population comprises two main religious groups: Muslims (50%) and Christians (40%). The remaining 10% consists of followers of indigenous religions. This highly varied mix of ethnicities and religious groups has led to violent conflicts and terrorism. These conflicts are exacerbated by the poor socioeconomic conditions, high unemployment, and widespread poverty. The Northern region has always been very fertile ground for religious activism, but in recent years the fundamentalist religious group Boko Haram has transformed into a terrorist organization, threatening the country's security and economic development (Ajayi 2012).

Good management practices are not currently in widespread use in poultry production (Nmadu et al. 2014; Ameji et al. 2012). Farmers are not generally knowledgeable about biosecurity, disease prevention, and modern husbandry practices, such as adequate feeding, housing and stocking to avoid overcrowding, proper disposal of wastes, cleaning, and disinfection.

While it has been shown that adopting innovations can bring about significant improvement in the productivity of poultry farming (Ameji et al. 2012; Aboki et al. 2013), the level of innovation adoption among family poultry producers is low in Nigeria. Nevertheless, innovation adoption is vital to reduce inefficiency. Contact with extension agents could help farmers access technological information and improve production and productivity through the efficient use of available resources and improved technology. The government of Nigeria purchases programs at the national, state, and community level to train farmers on improved and modern rearing and production methods (Aboki et al. 2013), but up to now, this has not had a significant effect on the majority of rural poultry farmers.

Technological Factors

For an agribusiness firm making the decision to invest in the poultry market in Nigeria, an important element of the technological environment is production type. Poultry is kept in two conventional systems: rural and commercial. Rural poultry systems are generally of small-scale, household, or grass-root tenure and receive little or no veterinary inputs.

Commercial poultry systems are industrialized and, therefore, based on large, dense, uniform stocks of modern poultry hybrids. They demand more capital, input, and technology and are the target market for foreign agribusiness firms. They house their animals in open-sided coops and employ the deep litter method. This design is cheaper than closed, environmentally controlled designs, but it exposes poultry to the vagaries of climate and weather with negative consequences for the productivity and health of stock. Tunnel ventilation fans, foggers, and cooling pads as well as shade trees are used to provide relief from overheating (Adene and Oguntade 2006). Watering and feeding is often manual, using troughs or buckets. More advanced integrated holdings use automated feeding and watering systems.

Eggs are mainly collected manually from nest boxes filled with straw or wood shavings. To keep out infections and minimize the need for medication, all-in–all-out systems are implemented on most commercial poultry farms. There are good housing, feeding, and husbandry standards, which especially entail daily standard cleaning and disinfecting of the environment, utensils, stock, and handlers to reduce the bacterial load. Vaccine application for disease prevention is also well established in Nigeria's poultry industry (Adene and Oguntade 2006).

However, most of the poultry is still kept in rural production systems, which are characterized by insufficient hygiene management. Even though many farmers would like to stock hybrids, which gain weight more quickly and are more disease resistant, their high mortality rates make hybrid production less profitable (Esiobu et al. 2014).

Furthermore, farm and flock size correlates significantly to the output of poultry farms. Large farm size increases productivity as well as technical, allocative, and resource use efficiency (Esiobu et al. 2014). Many poultry farmers still work at a subsistence, small, or medium-sized level mainly due to limited financial resources (Aboki et al. 2013). The above-mentioned micro-credits might help encourage farmers to expand their operations and therefore become more productive (Aromolaran Adetayo et al. 2013).

Ecological Factors

Nigeria has highly diversified agroecological conditions, making it possible to produce a wide range of agricultural products. About 40% of the land is arable, creating major agricultural opportunities (PwC 2014), but only 50% of the country's cultivable agricultural land is under cultivation. This land is cultivated mainly by smallholders and traditional farmers, who use rudimentary production techniques (Manyong et al. 2005). In spite the huge land reserves, adequate land and space is not always available for poultry farmers, some of whom see their expansion limited by the current land market (Aromolaran Adetayo et al. 2013).

Another constraint on Nigeria's poultry sector is the persistent scarcity and high cost of feed inputs, mainly corn and soybean meal. The irregular and limited supply of all raw materials grown in Nigeria presents serious problems for local producers. As a result, the majority of feed millers in the country are turning to imported soft wheat to satisfy their energy requirements in feed ratios as an alternative to corn (USDA 2002).

Most of the corn and soybean used is imported, as well, since the quantity and quality of the corn and soybean cultivated in Nigeria does not meet the demands of the population. But still, the scarcity and high cost of the imported feed force producers to reformulate the poultry diet in favor of low quality substitutes such as peanut cake, cottonseed, and palm kernel meal (World Poultry 2013).

Nigeria's energy sector also performs poorly; 54% of Nigerian manufacturers consider unreliable access to power the greatest constraint on efficient production. Outmoded transmission facilities, natural gas supply shortages, and gas pipeline vandalism in the Niger Delta are the primary problems. Although the government has poured more than US $10 billion into the sector in recent years, service has continued to decline over that period. Most businesses rely on generators, making Nigeria one of the most energy-intensive countries in the world.

Nevertheless, Nigeria has the largest natural gas reserves in Africa, so if infrastructure and security improve, this could be a great opportunity for future investment (PwC 2014).

Climatic conditions in Nigeria are characterized by hot, wet weather. Most of the year, temperatures are above 30 degrees Celsius. The amount of rainfall varies greatly by region. Areas along the coast and some eastern areas receive large amounts of precipitation, while the semi-arid Sahel region in the North has to cope with very little rain (Our Africa 2014). Irrigation systems cover only about 3% of the total cropland, which exposes agricultural production to high seasonal precipitation variability (Ayinde 2010). Excessive flooding during past decades has hurt farming in coastal areas, while desertification is ravaging the Sahel (Apata 2011).

Nigeria has water resources in excess of 20 million hectares of water bodies. Nevertheless, the country faces severe water shortages for domestic and agricultural purposes mainly due to its inadequate water redistribution infrastructure, which limits water supplies, particularly irrigation. Fresh water is often polluted by industrial and domestic waste and oil spillage. Furthermore, climate variability and increasing temperatures due to global warming result in additional water loss. Moreover, inadequate management of water resources, especially of large bodies of water and irrigation technologies, increase water consumption.

The federal Ministry of Water Resources has developed a strategy to overcome these challenges. Research studies are being conducted and the education of professionals in this area is being expedited. The situation in northern Nigeria is receiving special attention due to the need for irrigation from the highly limited water resources in this area. About US $500 million have been invested to complete and rehabilitate existing irrigation schemes and dams in order to improve the irrigation water management system (FAO 2013).

Legal Factors

Because the agricultural sector is crucial for economic growth and the reduction of poverty, the Nigerian government is promoting investment in this sector. Companies engaged in agriculture-related businesses are not liable for minimum tax. Furthermore, companies entering the market are exempted from income tax for the first three years with a possible two-year extension.

There is no restriction on the capital allowances that can be claimed by such companies up to 66% of assessable profit, and the interest earned from agricultural loans is tax exempt, provided the moratorium is not less than 18 months and the rate of interest is not more than the base lending rate at the time of loan (KPMG 2013).

The surging food demand in sub-Saharan Africa has pushed food imports to a record high. In 2011 the region`s total agricultural imports from all suppliers reached US $43.6 billion. Wheat was Nigeria's largest single import, reaching nearly US $6 billion. In fact, Nigeria is the main importer of wheat in sub-Saharan Africa. However, as noted above, the government has also passed certain import prohibitions, such as poultry, to safeguard local production. (Nicely 2013).

To promote the export of agricultural goods, the government has decided to minimize administrative controls on external trade through trade liberalization and to promote competitive international trade. Nigeria is a member of the World Trade Organization and abides by agreements reached on international trade (FAO 2006). Continuing low prices on world markets have had a discouraging effect, and, as a result, agricultural exports (including manufactured food and agricultural products) have decreased in recent decades. This and the fact that Nigerian poultry production is intended to meet the needs of the Nigerian population mean that exports play a minor role in this particular agribusiness subsector (Encyclopedia of the Nations 2014).

Results of the SWOT Analysis

All the above-named factors influence the investment decision of agribusiness companies in the Nigerian poultry market and have been sorted into a SWOT matrix depending on whether they represent strengths, weaknesses, opportunities, or threats (Figure 1). A PESTEL factor is categorized as strength if it has the potential to positively influence a market entrant's business but as a weakness if its effect is likely to be negative. Furthermore, a factor creates an opportunity if its influence is expected to stay favorable or to improve in the future; it is considered a threat if no improvement or even deterioration is expected in the future.

The SWOT analysis shows that most of the external factors are categorized as present weaknesses but also as future opportunities. This means that their current state is unfavorable but that their development shows great promise for future improvement. Twenty-eight factors can clearly be assigned to this quadrant. In the strengths–opportunities quadrant, there are 10 factors. These factors already constitute strengths and therefore already have the potential to attract foreign investors into poultry production. Seven factors could not be definitively classified and straddle the line between strengths and weaknesses. These factors are well on the way to becoming strengths but still have some weaknesses or need more consistent practical implementation.

In the weaknesses–threats quadrant, there are only two external factors. Another three factors could not be clearly classified and are therefore located between the weaknesses–opportunities and the weaknesses–threats quadrants. No external factors were assigned to the quadrants strengths–threats or weaknesses–threats, but one straddles the line between them. The factor governmental stability could not be placed in a specific category and therefore appears in the center of the SWOT matrix.

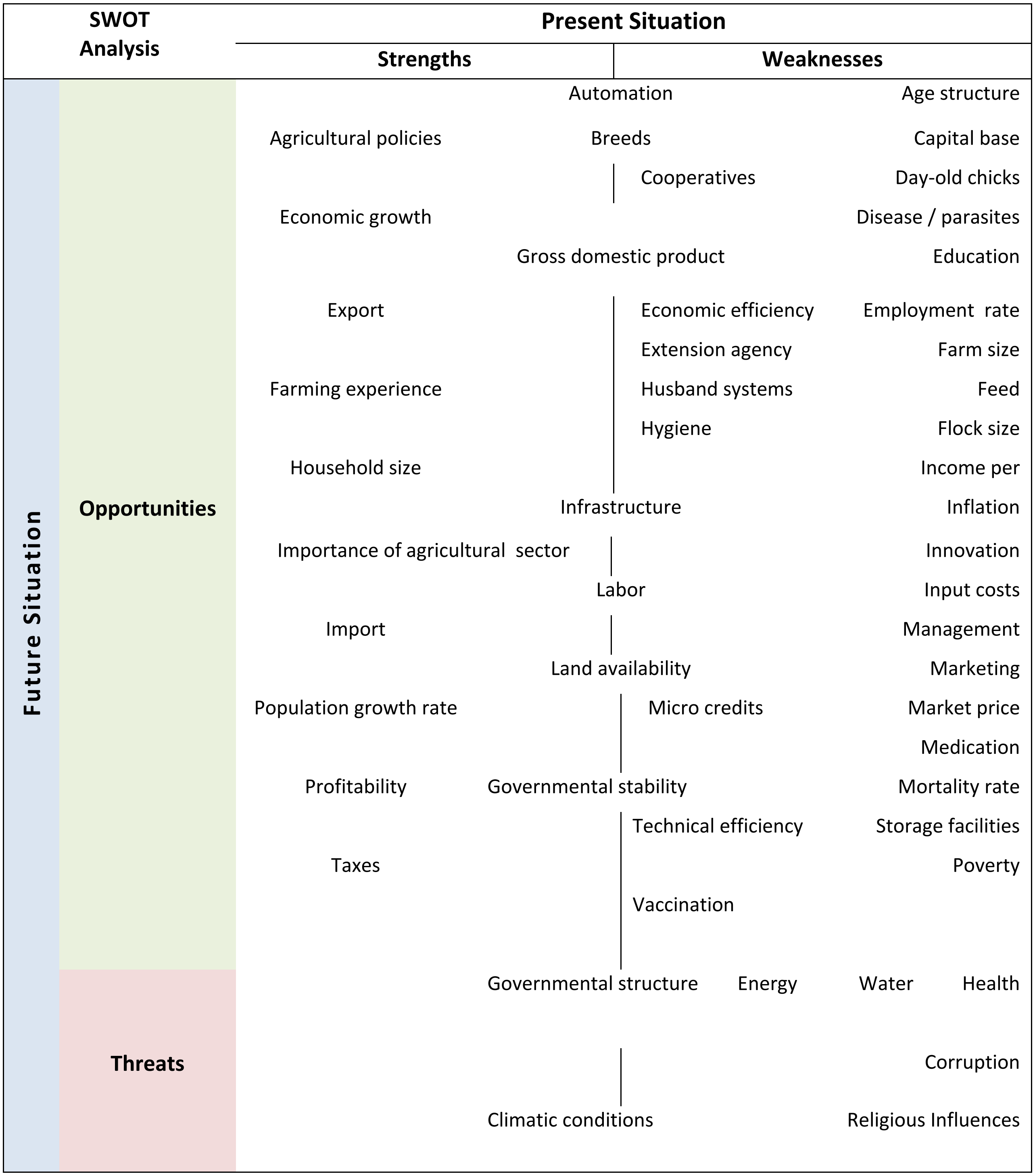

Figure 1. SWOT Analysis of the Nigerian Poultry Market

Discussion

The PESTEL and SWOT analyses show that the market for poultry products in Nigeria cannot be assessed as clearly positive or negative but reveals a mixed picture. It is often the case in emerging and developing economies that there are some promising aspects, such as favorable agricultural policies, strong GDP growth, and growing demand, but also challenges, such as poverty, high unemployment, and corruption. Agribusiness firms internationalizing their business activities often perceive these weaknesses as major impediments to the successful implementation of their internationalization strategies (Theuvsen et al. 2010).

Many environmental factors influencing a market situation constantly change over time. Unforeseeable future events always lead to significant uncertainty for investors. The SWOT analysis shows that there are many factors that currently represent strengths and may create even more promising opportunities in the near future. These factors are primarily of an economic, political, sociocultural, or legal nature. Economic and population growth will lead to high demand for poultry products (Abdullah et al. 2011; Steinfeld 2003). The government has reacted to this and is attempting to support private investment through the liberalization of agricultural policies. Taxes on investments in the agribusiness sector are often reduced or entirely suspended, while exports (with a few exceptions) are strongly encouraged through various incentives (Nigerian Investment Promotion Commission 2014). Participation in farmer co-operatives, extension and training facilities for farmers, and availability of micro-credits for smallholders are already supported by the government but need even more widespread implementation in the near future (Aboki et al. 2013).

All these factors are important for market development and encourage the market entry of international investors. Prospective changes in factors that are currently perceived as weaknesses provide huge opportunities for the poultry market in Nigeria. These weaknesses are the high poverty rate, high unemployment, low education levels, and health problems (African Economic Outlook 2012; World Health Organization 2014;Byerlee et al. 2013). Many factors that are directly linked to poultry production currently remain weak, but are well on the way to improvement in coming years. Even though the technological development of many production factors lags behind international standards, poultry production is already highly profitable for many farmers in Nigeria (Aboki et al. 2013; Nmadu et al. 2014; Ohajianya et al. 2013).

Difficulty in improving the status quo and the risk of unforeseen changes, for instance, with regard to important policies, the political framework, and internal security, require careful risk management on the part of international investors. One way to mitigate the risks a multinational company faces is regional diversification. Agribusiness firms also need to look for local strategies that could help reduce their exposure to risks; such strategies include collaboration with local investors, who have a better understanding of the local PESTEL situation, know how to deal with local authorities, and contribute a dense social network (Mhlanga 2010).

Most poultry production is done on a rural, backyard basis. Efforts are underway to commercialize the poultry sector and increase its efficiency (Adene and Oguntade 2006). Some of the weaknesses have already been addressed, including major work on infrastructure, the use of modern breeds, and the implementation of a democratic federal government. These factors have been significantly improved in recent years but need further advancement if they are to be converted into strengths that can help attract foreign direct investments into the Nigerian agribusiness sector.

Some factors represent weaknesses at this point in time, and it cannot be clearly foreseen whether these weaknesses will turn into opportunities or become major threats in the near future. This is especially true of the health status of the population and the reliability of the energy and water supplies (PwC 2014). Therefore, these factors will need to be reevaluated in the future to see whether they become opportunities or threats for the Nigerian poultry market.

Two factors currently present major problems for the country and have the potential to cause major threats. First of all, Nigeria is still one of the most corrupt countries in the world, meaning that revenues are not handed down to the population, significantly slowing growth in their prosperity (Falola and Heaton 2008; Bergstresser 2010; Bach 2006). For foreign companies, corruption can create problems, especially when they are first trying to enter the market. In this case, local acceptance of corruption often comes into conflict with governance and compliance rules in the agribusiness firms' home countries or with the expectations of nongovernmental organizations and the wider public concerning compliance with good management practices (Mhlanga 2010). The second major risk stems from the wide variety of religious and ethnic groups, which continue to represent a huge potential for conflict (Ajayi 2012). In particular, the activities of the Boko Haram terrorist network create a severe security risk for the whole country and for foreign investors, as well. At present, there are no comprehensive solutions for the abatement of corruption and terrorism, making them the most restricting factors for market investment.

Nonetheless, even if there are significant restrictions on a problem-free market entry for investors from foreign countries, the SWOT matrix clearly illustrates that most of the external factors have the potential to fuel an expansion of the Nigerian poultry market and make it more attractive for private investors. In the areas of feed, breeding, husbandry systems, automation of workflows, hygiene, medication, and vaccination, Nigeria depends predominantly on products from developed countries. Furthermore, specialized knowledge is needed to successfully implement new technologies and production methods (Adene and Oguntade 2006). These core areas constitute potential entry opportunities for agribusiness companies from developed countries.

Conclusions and Implications

This paper has provided a detailed overview of the conditions of poultry production in Nigeria. The PESTEL analysis describes 52 political, economic, sociocultural, technical, ecological and legal external factors that influence the Nigerian poultry market and therefore play a decisive role in investment decisions.

These factors were analyzed and sorted into the SWOT matrix categories of present strengths and weaknesses as well as future opportunities and threats. It has become obvious that the

Nigerian poultry sector offers potential investors various possibilities when entering the market. Nevertheless, there are also risks, especially because of corruption and terrorism, which carry unforeseeable implications for Nigeria, the Nigerian poultry market and private investors. The unsteady security situation should be given special consideration when making decisions about investing in this country (Ajayi 2012).

A PESTEL analysis in combination with a modified SWOT analysis constitutes a suitable methodology for acquiring an overview of relevant information about a potential market and for analyzing the opportunities and threats of market entry. However, the database for an in-depth analysis of the Nigerian poultry market is partly obscure, and the procurement of relevant information is very time consuming. The more precise and accurate the data that are fed into the PESTEL and SWOT analyses, the more specific and reliable the recommendations for investment decisions will be. In this paper, it was possible to collect the most important factors that influence a market entry decision despite the various obstacles that had to be overcome. Nevertheless, the SWOT analysis could be even more finely tuned if more information were publicly available. Furthermore, since its external conditions are constantly changing, the Nigerian poultry market should be reexamined regularly. Political and legal factors in particular may change in the short term and should be reexamined on a case-by-case basis.

Nevertheless, the results of these preliminary PESTEL and SWOT analyses already show interesting implications for agribusiness companies looking for new business opportunities. The results parallel earlier findings, which showed that African countries have increasingly come into the focus of European and other Western agribusiness firms (Theuvsen et al. 2010; Connolly 2014; von Rooyen 2014).

The sub-Saharan region constitutes a part of the world where economic and population growth is high. As a result, these countries offer interesting investment opportunities for private investors all over the world. However, political, economic, social, technical, ecological, and legal conditions differ significantly among these countries. It would be interesting to conduct a comparison of all African countries where poultry production has been increasing, so that investment decisions might be made on the basis of these expanded data and a cross-country comparison.

Finally, the study of best practice examples from multinational companies successfully serving African markets could generate empirical insights into successful designs of future market entries even better adapted to prevailing circumstances. These will most likely be found in other agribusiness subsectors where experienced investors have already successfully entered various African markets and established local subsidiaries, such as the brewing industry (Klein and Woecke 2007).

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

HPAI Impact on EU-27's Import Demand for Cooked and Uncooked Poultry and Other Meats[1]

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Abstract

The article applied a Central Bureau of Statistics (CBS) differential model to evaluate the impact of HPAI (H5N1) virus outbreaks on EU-27's import demand for five meat products: cooked poultry, uncooked poultry, beef, pork, and other meats. One novel feature of this work is the division of poultry into two distinct import products—cooked (safe) and uncooked (less safe). Analysis shows that HPAI (H5N1) outbreaks had statistically significant impacts on EU27 import demand for meats, increasing cooked poultry and decreasing uncooked poultry, beef, pork, and other meats. The shift in import demand regime was permanent and statistically significant, making cooked poultry imports EU27's largest, averaging more than 50 percent of EU imports in 2013 and 2014.

Keywords: CBS model, Highly Pathogenic Avian Influenza (HPAI), meat import demand system, cooked poultry, uncooked poultry, structural change, EU27.

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[1] The views expressed here are those of the authors, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

Introduction

Outbreaks of animal disease can affect production, consumption and global trade. One disease that has had an effect on the world market for poultry meat is the Highly Pathogenic Avian Influenza virus HPAI (H5N1)[2]—commonly known as “bird flu.” The disease spread out from Asia to Siberia, Russia, Central Europe, the Middle East, Africa, and eventually to the European Union (EU27) in 2006 and early 2007. Millions of EU27 birds died or were culled, and EU27 production declined 4.1 percent. Prices plunged, and demand for poultry meat declined (European Union Commission 2006).

HPAI can also infect humans. The virus outbreaks had been confirmed in 62 countries, with 650 human cases and 386 fatalities, as of February 2014 (World Health Organization 2014). Most human infections are caused by contact with live birds or with their uncooked meat. The World Organization for Animal Health (OIE, October 2005) and the David E. Swayne of the Southwest Poultry Research Laboratory (Swayne 2006) provided scientific evidence that cooking poultry meat kills the H5N1-virus, making poultry meat safer to handle and consume.

Research has shown that HPAI outbreaks have decreased the demand for poultry in many countries (Some of these studies are reviewed below). About the time of the HPAI outbreak, EU27 uncooked poultry imports started to decline and cooked poultry imports to increase. EU statistical trade data indicated that from 2005 to 2014, imports of cooked poultry meat more than doubled—from 314,000 metric tons to 665,000 metric tons—while imports of uncooked poultry declined sharply from 440,000 to 144,000 metric tons during the same period. Imports of all other meats declined substantially (Table 1).

The objective of this research is to investigate the impact of HPAI (H5N1) outbreaks on the EU27 meat import system after the 2006-2007 outbreaks. Did consumer concerns about the safety of poultry meat cause a demand shift toward safer products?

All previous studies concerning the impact of animal disease outbreaks and consumer behavior focused on the possible substitution of one fresh meat for others. For instance, following the BSE outbreaks in Europe in the 1980s and elsewhere, several economic studies demonstrated a consumer shift from fresh beef toward other fresh meats such as poultry, pork, and seafood. A unique feature of this report is splitting the potentially risky poultry meat into two categories with different levels of risk: cooked meat (where the pathogens are killed) and uncooked (that might contain pathogens).

We begin with a literature review, followed by an examination of EU-27 meat import volume, prices, and expenditure shares from January 1999 to 2014, a discussion of the methodology, empirical results, and conclusions.

[2] Avian flu strains are classified as either high pathogenic or low pathogenic, based on the severity of the illness experienced by the bird population. With low pathogenic strains, the illnesses are not severe and affected birds usually recover.

Literature Review

There is widespread concern about HPAI because it is potentially fatal to humans. Bovine Spongiform Encephalopathy (BSE) provides another example of an animal disease that can be fatal to humans. BSE has been an issue longer than HPAI, and people's reactions to the disease might give us insights into their reactions to HPAI.

The discovery of BSE in the United Kingdom (UK) in 1986 triggered a shift away from beef consumption toward pork, chicken, and lamb (Burton and Young 1996; Henson and Mazzocchi 2002; and, Leeming and Turner 2004). Consumer fear of eating beef intensified after the British Government announced on March 20, 1996, the possible fatal link between BSE and a new variant, Creutzfeldt-Jakob disease (vCJD), which is potentially fatal in humans. Sharp declines in fresh beef consumption were reported in many other countries besides the UK (Atkinson 2003), including France (Latouche et al. 1998), the Netherlands (Mangen and Burrell 2001), Belgium (Verbeke et al. 2000; Verbeke and Ward 2001), Japan (Peterson and Chen 2005), and the United States (Schlenker and Villas-Boas 2009).

The (HPAI) (H5N1) virus was first isolated from a goose farm in Guangdong, China in 1986. The first HPAI outbreaks were reported in poultry farms and live animal markets. One year later, Hong Kong reported 18 human cases with six fatalities. Between late 2003 and early 2004, the virus reemerged and gained global attention when it was found in the poultry sectors of most East and Southeast Asian countries and spread to Russia, Kazakhstan, Turkey, the Middle East, Africa, and Western Europe in 2005-2007. As of February 2014, HPAI outbreaks had been confirmed in 62 countries, with 650 human cases and 386 fatalities (World Health Organization 2014).

Several studies have addressed impacts of HPAI outbreaks on domestic and international meat markets and have reported substantial disruption in poultry production, consumption, prices, and/or trade in many countries. In Vietnam, one month after HPAI struck Hanoi in January 2004, 74 percent of consumers initially stopped eating poultry meat or adopted alternative ways of preparing it to assure food safety (Figuie and Fournier 2008). In Taiwan, consumers were well informed about health risks associated with the disease and reduced their poultry consumption while increasing consumption of pork and seafood (Liu et al. 2007). In South Korea, Park, Jin and Bessler (2008) reported that the December 2003 HPAI outbreak, which occurred simultaneously with the first U.S. BSE case, causing poultry prices and consumption to decrease and demand for pork to rise. In Japan, Ishida et al (2010) reported that the 2003-04 HPAI outbreaks decreased domestic demand for chicken, increased demand for pork and fishery products as substitutes, and had no impact on beef. Onyango, et al. (2009) indicated that during HPAI outbreaks, consumers no longer viewed poultry meat as one homogenous product, but as three segmented products based on the perceived food safety risk. Paarlberg et al. (2007) analyzed the economic impacts of a hypothetical HPAI outbreak in the United States, concluding that the largest impact would be in the first quarter following the outbreaks.

EU-27 Meat Imports, Expenditures, and Unit-Values

Table 1 shows the yearly volume of EU imports of five classes of meats: cooked poultry, uncooked poultry, beef, pork, and all other meats. (All other meats consisted mainly of sheep, lamb, or goats, horse, and offal.) Imports of both types of poultry increased every year between 1999 and 2005. In 2006, the year (HPAI) (H5N1) virus first had a major appearance in the EU27, uncooked poultry imports declined. From 2006 to May 2014, cooked poultry volumes were generally rising while uncooked poultry volumes were declining. The fact that uncooked poultry started to decline when the EU had an HPAI outbreak is consistent with a demand shift away from uncooked to cooked poultry. In addition, Table 1 shows that beef, pork, and other meat imports were generally declining in the post-HPAI period. Figure 1 takes the quantities from Table 1 and turns them into indices with 2006 as the base, indicating a substantial increase in cooked poultry imports and a general decline in the other four classes of meat during the post-HPAI period.

Table 2 shows the unit-values for the five types of meat imports, a measure of the imported meat prices. Most years' unit values are higher than the previous ones. Uncooked poultry is always the least expensive of the five meat-types in the entire sample period. Over the post-EU-HPAI outbreak period of 2006-2014, the unit-value of pork and beef nearly doubled, while cooked poultry in comparison with uncooked poultry was imported at 39 percent premium in 2014 (Table 2). However, cooked poultry prices were less expensive than those of beef, pork and other meats.

Table 1. EU Imports of Meats by Type in Metric Tons[1]

Year	Cooked Poultry	Uncooked Poultry	Beef	Pork	Other Meat
1999	105,030	129,112	293,685	24,207	348,307
2000	195,682	129,158	285,697	14,467	344,464
2001	351,310	142,570	267,259	24,427	375,888
2002	341,426	163,079	344,388	24,158	337,053
2003	325,613	309,479	363,698	33,625	338,855
2004	231,878	368,728	425,611	40,703	335,618
2005	314,638	440,118	472,666	76,467	345,434
2006	434,333	303,383	475,759	95,788	348,999
2007	596,460	213,914	416,452	26,350	342,229
2008	651,406	213,255	301,377	43,430	339,867
2009	640,126	198,443	317,298	29,624	335,223
2010	634,180	166,793	288,292	19,193	299,154
2011	654,360	175,170	242,289	14,562	274,846
2012	694,347	173,521	233,175	15,021	240,631
2013	670,477	144,099	252,508	12,191	247,763
2014	665,330	143,539	238,678	12,305	281,002

[1] **Source.** World Trade Atlas. The First EU HPAI outbreak occurred in late January 2006.

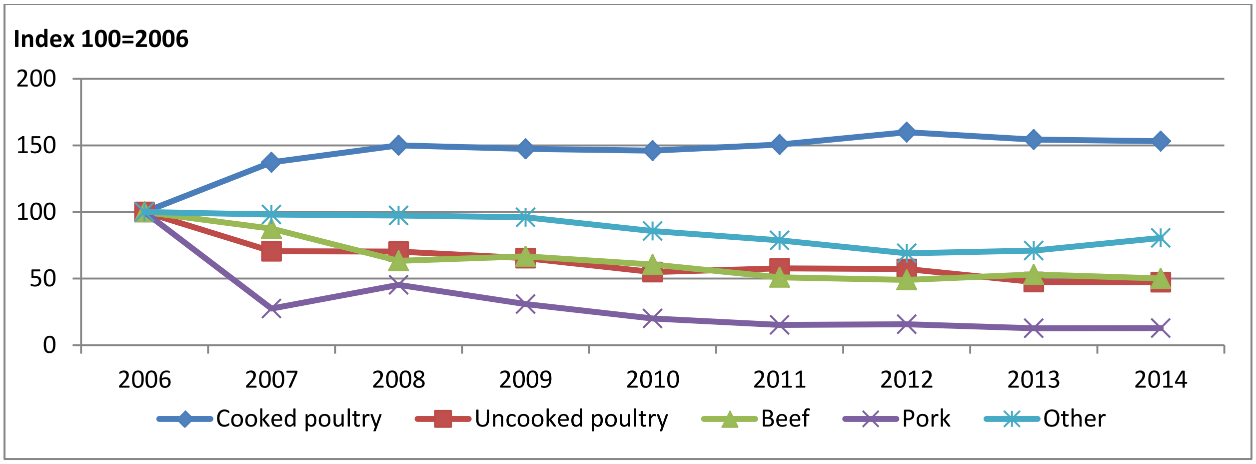

Figure 1. EU27 Indexes for Meat Imports by Volume, 2006-2014.
Source. World Trade Atlas.

Table 2. EU imports unit values in U.S. dollars per ton[1]

Year	Cooked Poultry	Uncooked Poultry	Beef	Pork	Other Meat
1999	3,198	1,989	4,572	2,403	3,494
2000	2,767	1,730	4,078	2,975	3,343
2001	2,623	1,860	3,300	2,958	3,523
2002	2,207	1,422	3,113	2,265	3,746
2003	2,455	1,515	3,439	2,322	4,122
2004	2,899	1,613	3,993	2,434	4,604
2005	2,683	1,646	3,915	2,354	4,987
2006	2,709	1,544	4,573	2,279	4,725
2007	2,966	2,315	5,655	3,728	4,985
2008	3,454	2,581	7,351	3,661	5,583
2009	3,057	2,109	5,917	3,205	5,027
2010	3,117	2,222	6,588	3,785	5,240
2011	3,452	2,486	8,606	4,720	6,619
2012	3,122	2,193	8,115	4,131	5,879
2013	3,179	2,296	7,624	4,153	5,279
2014	3,253	2,217	7,823	4,497	5,745

[1] **Source.** World Trade Atlas.
2014 data based on January-May. First EU HPAI outbreak in late January 2006.

The Applied Demand Model

The primary focus of this research is to discover what effect, if any, the outbreaks of HPAI had on EU27 meat import demand. To answer this question, we estimate a demand system for five classes of imported meats, using monthly data from January 1999 to May 2014, consisting of

185 observations, to test the system for HPAI effects. The five meats for analysis are the five classes previously discussed: cooked poultry, uncooked poultry, beef, pork, and other meats. The quantities in the applied demand analysis are metric tons. The unit values are the prices.

What Could We Expect to Find?

The rise in cooked poultry demand that started after the EU HPAI outbreak would leave us to expect that the outbreak might have something to do with the increase. One the other hand, the unit values show that cooked poultry became a better deal relative to most of the other meats in the post-HPAI period, which should also lead to an increase in its imports.

We could theoretically justify almost any change in import demand for poultry. For instance, the EU will not import poultry meat from infected countries unless it is made safe by cooking. Since uncooked meat would come from HPAI-free countries and cooked meat is free of the virus in any case, imported poultry of both types might be perceived as safer than EU-raised poultry; leading to increased demand for raw as well as cooked poultry meat. The loss of EU poultry production due to HPAI could have also expanded the demand for imported poultry. However, EU consumer concerns could as well have decreased demand for all types of poultry, even the safer cooked poultry. Our objective was to determine the actual cause behind the rise in EU demand for cooked poultry.

Reasons for Choosing the CBS Empirical Model

Our applied demand model is the CBS model of Keller and Van Driel (1985). They developed the CBS as a model of consumer demand that can be made consistent with optimization theory. Imported meat is an intermediate good; it must be further processed prior to final sale. However, Theil (1977) demonstrated that consumer demand systems like the CBS could be used to model cost-minimizing input demands. One merely needs to reinterpret some of the terms. Our demand analysis is conditional on market “scale.” Scale is a measure of the total amount of output produced from the imported meats. We will not attempt to discover if HPAI had an effect on EU27’s scale of import demand.

The CBS is a differential demand model. One advantage of differential models is that it is easy to put taste shifters directly into these models while keeping them consistent with theory. Putting demand shifts in models based on primal-dual functions, for example the Almost Ideal Demand System, AIDS is more complicated. See Alston, Chalfant, and Piggott (2000), who discussed these issues in the context of modeling advertising’s effects on demand.

The CBS has two more appealing features. First, Keller and Van Driel demonstrated that the CBS is a flexible functional form, meaning that the model is able to generate any set of demand elasticities for a given set of prices and quantities. Technically, these set of elasticities do not need to be consistent with optimization theory; making demand elasticities consistent with optimization requires restrictions on the CBS coefficients. Second, theory requires that the own-price and cross-price derivative matrix of cost-minimizing input demands should be negative semi-definite (NSD). Keller and Van Driel demonstrated that the CBS will be globally NSD if its price coefficients are locally NSD[3].

The CBS Model as Applied to Input Demand

Our discussion of the CBS model will be brief, mainly focusing on modeling the effects of HPAI on import demands. Those readers interested in more detail on the CBS and other differential models can find them in Barten and Bettendorf (1989), who discuss three differential demand models and their inverse forms, the Rotterdam, the CBS, and the differential AIDS, or DAIDS. Eales, Durham, and Wessells (1997) build a composite demand system using these three models and the NBER model.

Let $q_{i,t}$ and $p_{i,t}$ stand for the quantities and prices of imports i={cooked poultry, uncooked poultry, beef, pork, and other meat} for the months numbered "t". We can define the symbols:

$$x_t = \sum_i q_{i,t} * p_{i,t},$$
$$w_{i,t} = \frac{q_{i,t} * p_{i,t}}{x_t},$$
$$\Delta Q_t = \sum_j \frac{1}{2}\left(w_{i,t} + w_{i,t-1}\right)\Delta \ln q_{i,t},$$
$$\Delta P_t = \sum_j \frac{1}{2}\left(w_{i,t} + w_{i,t-1}\right)\Delta \ln p_{i,t}, \text{ and}$$
$$y_{i,t} = \frac{1}{2}\left(w_{i,t} + w_{i,t-1}\right)\left(\Delta \ln q_{i,t} - \Delta Q_t\right)$$

The term x_t is the total expenditure on the goods in period "t." Since we are treating the CBS as a derived demand system, x_t is the objective of the importing firms. Total expenditure is a constraint for consumer demand cases. The "w" terms are the costs shares, while ΔQ_t and ΔP_t are changes in quantity and price indices. The quantity index is often called the "scale" term. Theil demonstrated that scale is a measure of the total output produced from the inputs under certain conditions. Finally, the term $y_{i,t}$ is the endogenous variable of our CBS demand model. The CBS endogenous variables sum to zero in every time period. A basic CBS demand model can be written:

$$\text{(1)} \quad y_{i,t} = \sum_k a_{i,k} z_{k,t} + \sum_j c_{i,j}\, \Delta \ln p_{j,t} + b_i \Delta Q_t + e_{i,t}$$

Equation (1) has some new exogenous variables, the $z_{k,t}$, and their coefficients, $a_{i,k}$. The basic set of "z" variables includes an intercept and monthly dummies. The $c_{i,j}$ are estimated price coefficients and the b_i are scale coefficients. Finally, we have a random error term, $e_{i,t}$.

We imposed the following restrictions on the coefficients to make the CBS estimates consistent with theory:

[3] Why all the concern about NSD? Researchers may want to use these estimates in future analyses of EU imports. One of the present authors has used published demand elasticities in building policy-analysis models. Sometimes these published estimates have not been NSD. Although the own-price elasticities of demand were negative, after inversion some of the own-quantity flexibilities of demand were positive!

(2) $\sum_i a_{i,k} = 0, \forall k,$

(3) $\sum_i c_{i,j} = 0, \forall j,$

(4) $\sum_i b_i = 0,$

(5) $\sum_j c_{i,j} = 0, \forall i,$ and

(6) $c_{i,j} = c_{j,i}, \forall\, i, j.$

In order for the CBS to be globally NSD, a matrix made of the $c_{i,j}$ coefficients must also be NSD. We imposed (equations 2-6) on the CBS estimates and also required that the matrix of $c_{i,j}$ be NSD.

As we noted above, the CBS endogenous variables sum to 0 in each time period. This makes the covariance matrix of the errors singular. The solution to estimating these types of demand systems is to drop one of the equations from the model and estimate the rest. One then uses (2), (3) and (4) to estimate the parameters of the excluded equation. If we use the maximum likelihood estimation, MLE, the estimates are independent of the excluded equation (Barten 1969).

Dynamic Adjustment

Because a month is a relatively short period, we modified (1) to allow for dynamic adjustment:

(7) $y_{i,t} + \sum_{l=1}^{L_y} \phi_l y_{i,t-l} = \sum_k a_{i,k} z_{k,t} + \sum_{l=0}^{L_x} \theta_l \left[\sum_j c_{i,j}\, \Delta \ln p_{j,t-l} + b_i \Delta Q_{t-l}\right] + e_{i,t}$

The symbols ϕ_l and θ_l are lag coefficients for the endogenous and exogenous; θ_0, the "lag" coefficients for the current prices and scale is set to 1. We have an implicit ϕ_0 that is also 1. Note that (7) may have different lag lengths for the endogenous and exogenous variables. The structure in (7) ensures that the CBS model is consistent with theory in all lengths of run.

The price and scale elasticities are going to vary over the length of run. The shortrun, cost-minimizing price and scale elasticities of the CBS demand function are:

(8) $\frac{c_{i,j}}{w_i},$ the short-run price elasticity of product "i" with respect to price j, and

(9) $1 + \frac{b_i}{w_i},$ the short-run scale elasticity of demand for product i.

The long run elasticities are:

(10) $\frac{c_{i,j}}{w_i}\frac{\sum_l \theta_l}{\sum_l \phi_l}$, the longrun price elasticity of product "i" with respect to price j, and

(11) $1+\frac{b_i}{w_i}\frac{\sum_l \theta_l}{\sum_l \phi_l}$, the longrun scale elasticity of demand for product i.

Note that we have dropped the time subscripts from cost-share terms (the w_i) in the elasticity formulas. CBS and other differential demand system elasticities vary with different budget shares. If all the b_i coefficients are 0, the scale elasticities are all 1 and EU meat import demand is consistent with constant returns to scale, CRTS. One of the side-issues we test is CRTS. We also test lag lengths for the endogenous and exogenous variables.

Differential Models and Demand Shifts

We model HPAI as a demand-shifting effect. The HPAI effects work much like the intercepts and seasonal dummies already included in the model. Typically, the intercept in a differential demand model is treated as a "taste" shifter (See Keller and Van Driel, 1985). Since we are dealing with input demands, the intercept will measure some mix of taste and technology changes. The monthly dummies are also taste/technology shifters; we would expect that there are more seasonal shifts in consumer tastes than in meat-processing technology. We would further expect that HPAI would affect consumer tastes for the final outputs more than meat-processing technology.

Barten and Bettendorf (1989) showed how the endogenous variables of the different differential demand models relate to one another. If there are no changes in prices or scale, the CBS and DAIDS endogenous variables are the same, at least at the derivative level. The DAIDS endogenous variable is the change in $w_{i,t}$, the cost share. If a good's intercept is positive, that implies an increasing share of total input cost will be spent on the good, all other things held the same (One good's positive intercept will need to be offset by one or more different good's negative intercept). In theory, we could solve for the price and scale effects on demand and then solve intercept, seasonal, and other taste-shifting effects. Any non-price, non-scale factor that increases the cost share by 1% in one month will basically increase the cost share 1% for all following months[4].

The intercepts and seasonal dummies are not differenced. If we take the first difference of a trend, we get an intercept. The intercept terms in differential demand models imply a type of trend in tastes and technology, or at least a trend in the cost shares.

The 12 monthly dummies and the intercept are perfectly collinear. We decided to identify the monthly dummies by making the 12 of them sum to 0 for each meat. The "trend" implied by the combination of the intercept and monthly dummies changes month-to-month. However, because we make the monthly dummies for each meat sum to 0 over the year; the seasonal effects cancel

[4] The lagged-endogenous-variable effects built into the dynamic specification will modify this effect.

and the intercept measures that "pure" trend effect (Another side issue we also test is the significance of the intercepts and monthly dummies).

Adding HPAI Shifts

Most of the disease-event studies cited above deals with a single outbreak of a disease. Those studies that track responses over time generally find that the initial response to an outbreak is more extreme than the longer-term responses. We wanted our HPAI effects to allow for differences in the short- and longrun responses. We also need to deal with the fact that the EU had a number of HPAI outbreaks spread over 14 months.

Table 3 shows the "events" we built into our model. The first EU HPAI cases were discovered so late in January 2006 that we treat February 2006 as the first outbreak month. The EU had outbreaks in February and March 2006. We also make April 2006 an "outbreak" month to allow for lagged responses to the first two months of outbreaks. There were outbreaks in July 2006; August 2006 gives us a potential lagged response to those outbreaks. There were more outbreaks in January and February 2007; we made March 2007 a lagged-outbreak month.

Table 3. The Outbreak Months

Events	Month	Disease Dummy Number
Greece & Bulgaria, Jan 30-31 put in February	Jan-06	
Italy and others	Feb-06	1
Poland and others	Mar-06	2
Lagged month	Apr-06	3
⋮	⋮	⋮
Spain, July 7	Jul-06	4
Lagged month	Aug-06	5
⋮	⋮	⋮
Hungary	Jan-07	6
UK turkey farm	Feb-07	7
Lagged month	Mar-07	8

We allowed HPAI to have three types of effects on demand: temporary, permanent, and trend. With eight events and three types of responses, we are adding 24 outbreak dummies to the model. These we denote $v_{t,o,d}$. The subscript o is for the "outbreak", o=1,2,…8. The "d" subscript is for the disease effect, d= {temporary, permanent, trend}.

We start with the trend effect. As noted above, non-0 intercepts imply a non-linear trend in demand. We allowed HPAI to change the intercepts. Statistically significant changes in the intercepts imply a change in these trends. The dummy variable for a trend effect would be 0 before the event and 1 in the event month and all following months.

As discussed above, anything that changes demand in one period changes it in all following periods. We would get a permanent change in demand if HPAI causes a one-time change demand in any (or all) outbreak months. The dummy variable for a permanent change is 0 for all months except the outbreak month, where it is 1.

For the temporary effects, we make the dummy variable 1 in the outbreak month and -1 the following month. The temporary effects work like the monthly dummies except that the monthly dummies cancel out over the course of a year and the temporary effect cancels itself out the following month. Note that one can get the permanent dummy for an outbreak by taking the first difference of the trend dummy and that of the temporary dummies by differencing the permanent ones.

Our most complex model defines the disease effects using three sets of estimated parameters. These are g_o, λ_d, and $f_{i,d}$. The term g_o is defined over the eight basic outbreak types; λ_d is defined over the response types, {trend, permanent, temporary} and $f_{i,d}$ over the meats and response types. If we set all the λ_d=0, we can write the model with HPAI effects as:

$$(12)\quad y_{i,t} + \sum_{l=1}^{L_y} \phi_l y_{i,t-l} = \sum_k a_{i,k} z_{k,t} + \sum_{l=0}^{L_x} \theta_l \left[\sum_j c_{i,j} \, \Delta \ln p_{j,t-l} + b_i \Delta Q_{t-l} \right] + \sum_{o,d} v_{t,o,d}\, g_o f_{i,d} + e_{i,t}$$

With the side constraints:

$$(13)\quad f_{i,d} = 0 \ \forall d$$

$$(14)\quad \textstyle\sum_o g_o = 1, \text{ and}$$

$$(15)\quad g_o \geq 0.$$

Equation (13) allows us to identify the disease effects for the excluded equation. We need (14) as an arbitrary equation to identify the system as a whole. For instance, we could double each g and halve each f and get the same net disease effect.

The disease-effect structure in (12) means that HPAI effects are consistent across the events. If one month's outbreak temporarily increases cooked poultry demand, all month's outbreaks temporarily increase, or at least do not *decrease* cooked poultry demand. That is why we require that each g_o be positive. Because the *g's* are shared across the types of reactions, events that cause large temporary effects also cause (relatively) large permanent and trend effects.

Our most complicated model uses distributed lags of the dummies; this is where the λ_d come into play. We introduce a non-stochastic state variable, $s_{d,t}$. Note that this is defined over the adjustment type. The state-variable is created-estimated using the following formula:

(16) $s_{d,t} = \lambda_d s_{d,t-1} + \sum_o g_o v_{t,o,d}$, with the side restriction that: $0 \leq \lambda_d \leq 1$.

Equation (16) defines the state variable as a first-order process of its lagged value, the g_o, and the disease dummies. The larger the value of λ_d, the longer it takes the state variable to adjust. For the more complicated model, the CBS function is written:

(17)
$$+\sum_{l=1}^{L_y} \phi_l y_{i,t-l} = \sum_k a_{i,k} z_{k,t} + \sum_{l=0}^{L_x} \theta_l \left[\sum_j c_{i,j}\, \Delta \ln p_{j,t-l} + b_i \Delta \right.$$
$$+ \sum_d s_{d,t} f_{i,d} + e_{i,t}$$

The slower adjustment of the state variables to HPAI shocks will make for more drawn-out adjustment to the HPAI events. We have put upper and lower bounds on the λ_d. If a λ_d is 1, we get an interesting effect; basically the underlying dummy variable gets undifferenced. Temporary effects become permanent effects; the implicit permanent effect's λ_d is 0. Making the permanent λ equal to 1 turns the permanent effect into a trend shifter. If the trend λ is 1, we end up with a squared trend.

Special Econometric Issues

Our specification of the HPAI effects raises a testing problem that Davies (1977) was the first to identify. He called it the "nuisance parameter" problem. Suppose that we want to test whether or not HPAI changed the trends in demand. We could test that hypothesis by running a model where all five *f* coefficients for the trend effect are 0. This would be a 4-degree of freedom restriction considering the restriction (13). However, if all the trend-*f* is 0, we cannot identify λ_{trend}. These nuisance-parameter cases violate the conditions that make coefficient tests asymptotically normal or chi-square. If we eliminate HPAI effects entirely, we cannot identify the g_o either—compounding the nuisance-parameter issue. Recall that the g_o and λ_d coefficients have upper and lower bounds; these bounds also violate the conditions that produce asymptotic normality.

We will use likelihood-ratio tests for model restrictions. For the nuisance-parameter cases, we will evaluate these tests using Monte-Carlo analysis. We will employ a constrained model's estimates to generate "new" observations and an empirical distribution for the tests. We can compare the actual test result to the Monte-Carlo test distribution to determine whether the actual test is significant.

Empirical Results and Interpretations

We performed some initial tests on the basic model structure prior to testing the HPAI effects. We started with six lags for the endogenous and exogenous variables in the dynamic specification outlined by equation (12). None of the exogenous-variable lags θ_l , l=1…, six are significant. The first two lags for the endogenous variables were statistically significant. We used the 2-endogneous variable lag model to test the intercepts, monthly dummies, and for constant returns to scale (CRTS). The intercept and 3 of the monthly dummies, April, October, and November, were statistically insignificant, as were the CRTS restrictions. These intercept, dummy, and CRTS restrictions were jointly insignificant as well. We used a model with these restrictions to test for the HPAI effects.

Testing HPAI Effects

Table 4 shows the likelihood ratio tests for excluding the HPAI effects from the model. In addition to the likelihood ratio tests, we show the estimated λ associated with each set of restrictions. Recall that when a λ's f coefficients are set to 0, that λ cannot be identified. The first three rows of Table 4 are tests of eliminating one of the HPAI-d type effects. If eliminating an HPAI effect were a 4-degree of freedom restriction and if these tests were chi-square tests[5], none of the single-elimination tests would be significant.

Table 4. Likelihood Ratio Test for HPAI Effects

		λ Estimates for the Constrained Models[1]		
Restrictions	**Test**	Temporary	Permanent	Trend
Temporary out	4.75		0.000	0.000
Permanent out	4.55	0.984		0.611
Trend out	1.39	0.293	0.509	
Temporary only	6.15	1.000		
Permanent only	6.15		0.000	
Trend only	52.99			0.000
All three out	56.54			

Note. [1] When an effect has been excluded, its cell is blank.

The next three rows show what happens when we use only one of the three HPAI effects, eliminating two of them. Note that results of the two tests; using only the temporary or the permanent effects are the same. They are not just the same to the decimal show in the table, they are exactly the same. If we use only a temporary effect, its λ goes to 1, turning the temporary effect into a permanent effect. Using only the permanent effect makes its λ go to 0. The permanent-only and temporary-only models are actually the same. The test value, 6.15, is not significant for a chi-square with 8 degrees of freedom. However, the tests for using only the trend effects or eliminating all three disease effects would be highly significant if they were distributed chi-square.

We did two sets of Monte-Carlo analysis on these tests. First, we evaluated the test statistic for using only the permanent effects, dropping temporary and trend. We used the permanent-only model's coefficient estimates to generate simulated sets of data. We used this simulated data to test the effect of adding back in the two (other irrelevant) types of effects, saving all the test

[5] The nuisance-parameter issue will prevent this test from being asymptotically chi-square. See Davies (1977).

iterations. We set up our Monte-Carlo program to do 5,000 iterations of the test but ended up stopping the program early.

Why did we stop early? We are using the conventional 5% critical value for our tests. We do not really need to know what the true 5% value for our test statistic is; we just need to know if our test statistic is above or below that value. Supposing that the value 6.15 was actually significant at the 5% level or above, we would see values 6.15 or greater 5% of the time (or less) in our Monte-Carlo iterations. In 383 iterations 337 of the tests, 88%, were larger than 6.15. With 383 observations 88% is highly significantly different from 5%. The second set of Monte-Carlo iterations tested eliminating the permanent effect for the model as well. We stopped early again, as in 726 iterations none of the Monte Carlo tests exceeded the actual test. With 726, an estimated 0% is also highly significantly different from 5%, implying that the actual test value is significant at over the 5% level.

HPAI Estimates and Implications

We allowed for three sets of HPAI terms; only one of these is significant, the “permanent” set. There is no change in the trend effect due to HPAI—an appealing effect given that the pre-HPAI meat import demand had no taste-technology trend either. Our final model uses only the permanent HPAI shifts. Since the λ for the permanent effects went to 0, we imposed that on the model as well. That means our HPAI effects can be written by multiplying the permanent v dummies, and the f_i and g_o coefficients as in equation (12). Table 5 shows the estimated permanent f coefficients and their standard deviations:

Table 5. HPAI Estimates and Effects[1]

	Disease Coefficients for Permanent Effects			**Longrun Shift in EU Import Demand Due to HPAI**		
	Estimate	Standard Deviation	z Statistic	Estimate	Standard Deviation	z Statistic
Cooked Poultry	0.1169	0.0549	*2.13*	0.0674	0.0317	*2.13*
Uncooked Poultry	-0.0696	0.0252	*-2.76*	-0.0401	0.0145	*-2.77*
Beef	-0.0218	0.0511	*-0.43*	-0.0126	0.0296	*-0.43*
Pork	-0.0869	0.0166	*-5.23*	-0.0501	0.0095	*-5.25*
Other Meat	0.0614	0.0532	*1.15*	0.0354	0.0308	*1.15*

Note. [1]Based on 5,000 Monte-Carlo iterations.

The HPAI coefficient for cooked poultry is positive and statically significant, while those for uncooked poultry and pork are negative and statistically significant. On the other hand, coefficients of beef and other meat were negative and positive, respectively, but statistically insignificant. These estimates imply that HPAI increases the demand for cooked poultry while decreasing it for uncooked poultry—essentially the results we would expect if the internal HPAI outbreaks made EU meat importers or their customers more concerned about the safety of uncooked poultry. Table 5 also shows the longrun impact of the HPAI demand shifts on EU27 meat imports. These coefficients are the *f* estimates divided by the sum of the lagged-endogenous variable coefficients.

Table 6 shows that the endogenous variable lag coefficients have quite small standard errors. The lagged endogenous coefficients are all positive; this makes current demand negatively related to lagged demand. Our estimates show that EU import demand has a tendency to overreact in the short run to changes in prices and HPAI.

The pattern of EU27 reaction to HPAI is going to depend on the g_o. Table 7 shows these estimates and confidence intervals. We show 95% confidence intervals rather than standard errors because the sign constraints on the *g* will insure that they are not normally distributed[6]. Our estimates imply a relatively small initial effect of HPAI in February 2006; the market reaction was stronger in March 2006. The next two "events" have 0 estimated weights. The remaining four event months all have non-0 weights.

Figure 2 shows our simulations of how demand shifted over time in response to HPAI. We only show 2006 and 2007 as the HPAI effects stabilize in mid-2007, a few months after the last EU outbreak. The largest changes in demand are associated with the outbreak in January 2007 (Figure 2; Table 7.)

Table 6. The Endogenous Variable Lag Estimates[1]

	Lag 0	**Lag 1**	**Lag 2**
Estimate[2]	**1**	0.4650	0.2701
Standard Deviation		0.0315	0.0345
z Statistic		*14.77*	*7.84*

Note. [1] Standard deviations and z statistics based on 5,000 Monte-Carlo iterations.
[2] The lag-0 estimate is fixed to 1.

[6] Even without the sign constraints, these estimates are unlikely to have a normal distribution. Normality is an asymptotic distribution for these types of models with nonlinearity and lagged-dependent variables. We have only eight observations to measure the HPAI effects, meaning they have no asymptotic properties.

Table 7. The "g" Estimates, the Weights for Each of the "Outbreak" Months

			95% Confidence Interval[1]		
Date	**Type of Event**	**Estimated Weight**	Upper Bound	Lower Bound	**Iterations when MC[2] Estimates are 0**
February-06	outbreak	2.65%	12.96%	0.00%	1,669
March-06	outbreak	17.53%	27.54%	6.22%	9
April-06	post-outbreak	0.00%	10.62%	0.00%	2,473
July-06	outbreak	0.00%	11.19%	0.00%	2,508
August-06	post-outbreak	26.22%	36.23%	14.28%	0
January-07	outbreak	35.58%	46.32%	22.07%	0
February-07	outbreak	8.98%	18.94%	0.00%	409
March-07	post-outbreak	9.03%	18.95%	0.00%	355

Note. [1] 95% confidence interval based on the 2.5th and 97.5th percentile of 5,000 Monte Carlo iterations.
[2] MC = Monte-Carlo.

The Model's Own and Cross-Price Elasticities

Table 8 shows the own and cross-price elasticities of demand implied by our CBS coefficient estimates. The Appendix has the CBS coefficient estimates underlying these elasticities. We use average budget shares for the post-HPAI period to calculate these coefficients. The scale elasticities are not shown in Table 8; when we accepted the hypothesis that EU27 import demand was consistent with constant returns to scale, we fixed the scale elasticities to 1.

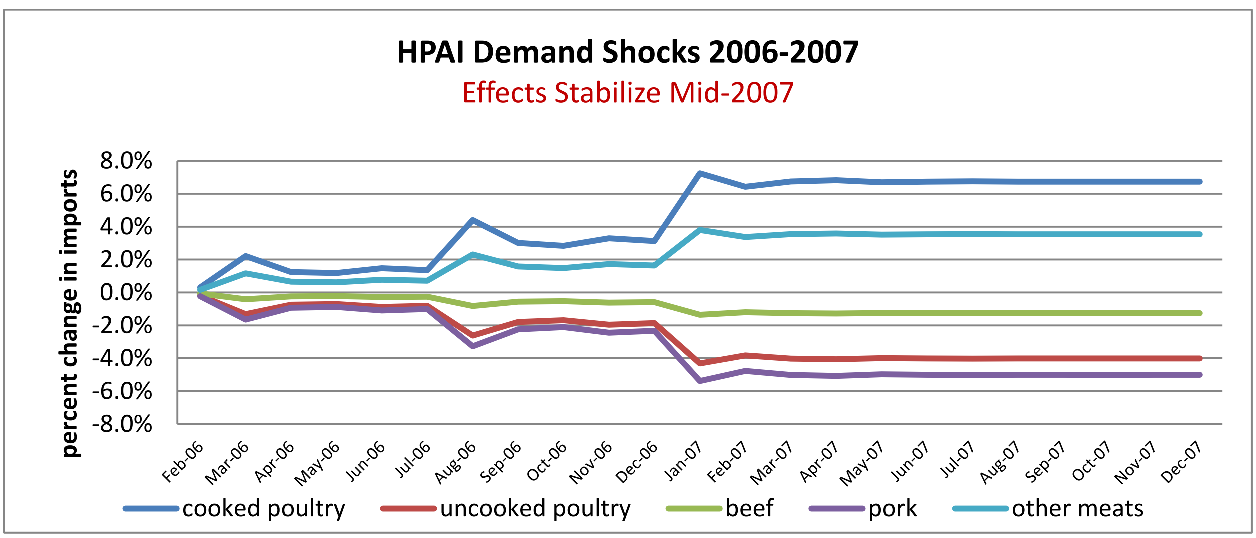

Figure 2. The HPAI Demand Shifts Implied by the Estimates

Table 8. Longrun Cost-Minimizing Price eElasticities of Demand

	Prices				
Quantities	**Cooked Poultry**	**Uncooked Poultry**	**Beef**	**Pork**	**Other Meat**
Cooked Poultry	-0.274	0.045	0.054	0.040	0.135
Uncooked Poultry	0.206	-0.109	-0.138	0.012	0.029
Beef	0.053	-0.029	-0.059	0.026	0.010
Pork	0.777	0.052	0.519	-0.640	-0.708
Other Meat	0.165	0.008	0.012	-0.044	-0.141
Cost Shares, Post-HPAI Average	32.03%	6.91%	33.22%	1.63%	26.21%

All the own-price elasticities are inelastic. We might generally expect that the demand for imports would be highly elastic. Typically, EU27 meat imports are a small part of domestic consumption-production and small changes in domestic conditions can lead to large percentage changes in trade. These, however, are cost-minimizing elasticities subject to output scale; these demands are likely to be much less elastic than the unconditional import demand elasticities.

Cooked poultry's cross-price elasticities with the four other meats are all positive, implying that it is a substitute for the rest of the meats. Import demand for cooked poultry increased as a substitute for uncooked poultry due to customer concern about the safety of uncooked poultry. In addition, due to the lower relative prices of cooked poultry, it was partly substituting for beef, pork, and other meat, causing EU 27 import demand for cooked poultry to increase.

Conclusions

After its HPAI outbreak, EU cooked poultry imports trended upward, while the other four meat classes we examined decreased over time. Our estimates were designed to determine what drove these trends in EU meat imports. The estimates show that HPAI is associated with statistically-significant increases in the demand for cooked poultry and statistically significant decreases in the demands for uncooked poultry and pork. Pork demand had a slightly larger percentage decrease than uncooked poultry demand (Figure 2). However, pork import volumes are the by far the smallest of the five meats (Table 1). The HPAI-related demand shift for uncooked poultry implies a much larger shift in the tonnage of uncooked poultry imports than the percentage decline in pork imports. However, as Figure 2 shows the EU market's response to HPAI was largely completed by mid-2007. The trends in meat imports after that are largely driven by price changes. Cooked poultry prices became an increasingly good bargain compared to the rest of the meats in the post-HPAI outbreak period.

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Appendix

The $c_{i,j}$ coefficient estimates and their Monte-Carlo "z" statistics are found in Table A1. Because these coefficients are symmetric, we show only the upper-triangular terms. Our use of "z" statistics in Table A1 is slightly misleading. For example, it would appear that two of the own-price terms are statically insignificant: uncooked poultry and beef. The $c_{i,j}$ were estimated subject to the condition that their matrix is NSD. None of the own-price terms is greater than or equal to 0 in any of the Monte-Carlo iterations. The monthly dummies and their z statistics can be found in Table A2. In this case the z statistics are more meaningful.

Table A1. ci,j Parameter Estimates and z^1 Statistics

		Cooked Poultry	**Uncooked Poultry**	**Beef**	**Pork**	**Other Meats**
Cooked Poultry	Estimate	-0.1522	0.0247	0.0303	0.0220	0.0751
	z statistic	*-4.28*	*1.77*	*1.36*	*2.48*	*2.87*
Uncooked Poultry	Estimate		-0.0131	-0.0166	0.0015	0.0035
	z statistic		*-1.38*	*-1.75*	*0.28*	*0.29*
Beef	Estimate			-0.0340	0.0147	0.0056
	z statistic			*-1.66*	*2.07*	*0.30*
Pork	Estimate				-0.0181	-0.0201
	z statistic				*-3.60*	*-2.50*
Other Meats	Estimate					-0.0642
	z statistic					*-2.23*

Note. [1] 'z" statistics based on 5,000 Monte Carlo iterations

Table A2. Monthly Dummy Estimates[1] and z Statistics[2]

Table A2. Monthly Dummy Estimates[1] and z Statistics[2]

		Jan	Feb	Mar	May	Jun	Jul	Aug	Sep	Dec
Cooked Poultry	Estimate	0.0081	0.0093	-0.0483	0.0100	0.0099	0.0174	0.0037	0.0058	-0.0159
	z statistic	1.38	1.65	-8.66	1.80	1.73	2.96	0.65	1.04	-2.90
Uncooked Poultry	Estimate	-0.0026	-0.0055	-0.0045	0.0048	-0.0002	0.0073	0.0100	-0.0006	-0.0087
	z statistic	-0.96	-2.12	-1.74	1.90	-0.07	2.74	3.88	-0.22	-3.39
Beef	Estimate	-0.0146	-0.0086	-0.0309	-0.0174	0.0385	0.0094	0.0181	0.0171	-0.0116
	z statistic	-2.64	-1.59	-5.85	-3.32	7.06	1.68	3.26	3.26	-2.17
Pork	Estimate	-0.0061	-0.0032	-0.0001	0.0040	-0.0008	0.0017	0.0022	0.0011	0.0011
	z statistic	-3.69	-1.97	-0.04	2.68	-0.49	1.02	1.32	0.73	0.70
Other	Estimate	0.0152	0.0080	0.0837	-0.0014	-0.0475	-0.0357	-0.0339	-0.0234	0.0351
	z statistic	2.63	1.43	15.10	-0.24	-8.44	-6.30	-5.94	-4.16	6.37

[1] The monthly dummies sum to 0 over the year. Those for April, October, and November are set fixed to 0 and not shown.

[2] ‘z’ statistics based on 5,000 Monte Carlo iterations

International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

To Have or Not to Have the Common External Tariff: The CARICOM Countries Conundrum[1]

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Abstract

This study utilizes a source-based demand systems model to estimate demand for imported poultry products in the Caribbean Community (CARICOM), and to evaluate the impact that modifications of the Common External Tariff (CET) would have on the demand for poultry products from the United States, Brazil, Canada and the European Union. Own price elasticities suggest that CARICOM's poultry import demand is highly price responsive in both the short run and the long run, and that any significant increases in imported poultry prices could be expected to trigger greater than proportional decreases in quantities demanded from all source countries except Brazil. Results also suggest that if the CET were removed, all source countries would be able to expand poultry product exports into CARICOM. Canada is the only country that would decrease exports to CARICOM in the long run if the CET were removed. Poultry exports to the region from most source countries would contract with a doubling of the CET to 80%, in both the short run and the long run.

Keywords: Caribbean Community (CARICOM); Central Bureau Statistics demand system; poultry import demand; price elasticity; Common External Tariff (CET)

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Introduction

Poultry is the most widely consumed meat type in the Caribbean. Statistics published by the Food and Agriculture Organization (FAO), estimated that poultry meat comprised 82% of all animal protein and 55% of all protein consumed in 2011. Average annual consumption across the region was reported as 35 kilograms per capita, with a range of 32-41 kilograms per capita across countries (FAO 2011). In recent years, the continued influx of poultry meat imports has caused Caribbean governments, the Caribbean Poultry Association (CPA), and other stakeholders to push for increased protection for the regional (domestic) poultry industry, as imports have tended to be more competitively and lower priced than domestically produced poultry meat (Agritrade 2011; 2012). Poultry meat and products imported into Caribbean Community (CARICOM) member states are subject to a Common External Tariff (CET). However, in practice, and as allowed by law, there is considerable variance in the rates that are actually applied, given that some countries also apply surcharges and taxes in tandem with the CET.

In an effort to be more competitive regionally and globally, the Caribbean Poultry Association (CPA) has been lobbying for modernization and an enhancement of regional tariff and regulatory frameworks for poultry products. Per the tariff regime specifically, this could involve an increase in the minimum CET from 40% to 80%, with a harmonization of supplementary levies (Agritrade 2012). Other suggested measures include (a) implementation of safeguard mechanisms linked to import licensing arrangements; (b) prohibitions on frozen products that are thawed and sold as fresh chilled products; (c) the introduction of country of origin labelling; (d) prohibitions on repackaging of imported frozen poultry parts; and (e) harmonization and strengthening of Caribbean sanitary and phytosanitary (SPS) regulatory systems that apply to poultry products (Agritrade 2011). If implemented, the aforementioned measures could affect the competitiveness of imported poultry meat and associated products. The United States (US), Brazil, Canada and the European Union (EU) are the main exporters of poultry meat and products to the Caribbean region, controlling 99% of the imported poultry supplies.

The study utilizes a source-based demand system model to estimate the Caribbean demand for imported poultry products and evaluate the impact that modifications of the Common External Tariff (CET), as applied by the countries in the Caribbean Community (CARICOM) group, would have on the exporting country demand. Given that CARICOM is a subgroup of the Caribbean region, issues faced by CARICOM states are consistent with those faced by the region at large. Two scenarios are evaluated. First, we assume a doubling of the CET rate to 80%. For agricultural commodity imports, the current CET employed by CARICOM member states is 40% on average, although there is some deviation in rates applied by individual members. Although doubling the tariff is contrary to global trade liberalization trends that include lowering of tariffs, we assume that CARICOM governments agree to double the rate in accordance with the CPA's lobbying efforts. The second scenario assumes complete removal of the CET, which is plausible under negotiated agreements that would liberalize trade between CARICOM and the source countries for poultry meat. This scenario is also plausible since there is precedence for the suspension of the CET. In 2008, CARICOM's Council for Trade & Economic Development (COTED) approved a suspension on three categories of food items (primarily) for specific time periods in order to ease the effects of rising costs of commodities across the region. Broiler meat was included in the list of items for some countries (CARICOM Secretariat 2008). Removal of the CET would essentially reduce the differential between the prices of poultry products in CARICOM countries, and consumers would pay lower prices for imported poultry meat from the various source countries. Table 1 lists the member and associate member states of CARICOM.

Table 1. Member and Associate Member States of the Caribbean Community (CARICOM).

Member States	Associate Members
Antigua and Barbuda	Anguilla
The Bahamas	Bermuda
Barbados	British Virgin Islands
Belize	Cayman Islands
Dominica	Turks and Caicos Islands
Grenada	
Guyana	
Haiti	
Jamaica	
Montserrat	
Saint Lucia	
St. Kitts and Nevis	
St. Vincent and the Grenadines	
Suriname	
Trinidad and Tobago	

Source. CARICOM Secretariat 2014.

As shown by Asche, Bremnes, and Wessells (1999), the study assumes that the level of market integration among poultry products allows for aggregation from species specific to a generic product category without significant loss of information, at least when assessing long-run relationships. This implies that products from broilers, turkeys and ducks can be represented as a single aggregate. However, as shown by Muhammad and Jones (2011) import preferences are not necessarily homogeneous across exporting countries and significant information loss can occur when source is not considered. Similar products from different sources may be physically different, which may be the case for the poultry products being studied. Short run and long run components are included in the model to account for the dynamic nature of the trading environment, where the inclusion of a long run time frame reflects market and resource allocation adjustments that are likely to occur following negotiated trade agreements (Jones and Blayney 2014).

Following this section, a brief discussion characterizing poultry meat importation into the Caribbean Community (CARICOM) is presented. This section focuses primarily on imports originating from the US, given its importance as a key supplier of food products to the region. Section 3 describes the regional poultry sector, and CARICOM tariff policy with implications for poultry meat trade. Methodology, data, model results and discussion are presented in Sections 4, 5 and 6, respectively. General implications for exporting countries (the United States, Brazil, European Union and Canada) and CARICOM (producers and consumers) are discussed in the final section of the paper.

Caribbean Poultry Meat Importation Trends

The Caribbean region comprises a set of countries with distinct country groupings including the continental countries of Guyana, Belize and Suriname, countries with sizeable populations (Haiti, Trinidad and Tobago, Dominican Republic, Cuba and Jamaica), and the smaller countries of the Organization of the Eastern Caribbean States (OECS) and Barbados. By definition, the countries are small, open economies that are easily affected by the ongoing events in the global economy due to their reliance on developed nations for trade, economic assistance and financial investment and high level of migration. The United States, the European Union and Taiwan provide ongoing support and assistance via different arrangements.

As the largest supplier of food products to the Caribbean, the United States has an estimated 55% share overall of the market for imported agricultural products. The Caribbean is the 7th largest export market for U.S. consumer-oriented foods, with poultry, red meats, dairy products and snacks comprising the top export categories (Gonzalez 2014). In 2011, the United States exported $823 million of consumer-oriented products to the Caribbean, and surpassed this in 2012 with a record breaking $1.4 billion in consumer-oriented product exports to the region (Gonzalez 2012; Gonzalez and Nishiura 2013). Geographical proximity of the Caribbean to the U.S, the strong appeal of U.S. products among island populations, urbanization, lifestyle changes and the expansion of tourism on most islands, as well as the decline in per capita agricultural production are among the factors that drive demand for U.S. products. With the exception of Guyana, Suriname and Belize, most countries are net food importers that have become increasingly dependent on food importation over time. In tandem, these socioeconomic conditions and characteristics of the Caribbean market would appear to augur well for increased demand for US agricultural and consumer-oriented products in the future, albeit depending on global economic conditions.

Between 2005 and 2009, US poultry meat exports to the Caribbean region grew 74%, surpassing total US poultry meat exports worldwide (AMS 2009). In 2009 alone, approximately 79% of all poultry meat imported into the Caribbean was sourced from the United States (Agritrade 2011). The Caribbean was the 5th largest export market for US poultry meat and products in 2012 (FAS, 2014), with US poultry exports to the region valuing $444 million – a record high (Gonzalez 2013). According to the Agricultural Marketing Service (2013), the region ranked 4th for US turkey meat and 5th for US broiler and other poultry meat exports, respectively, in 2013. Poultry meat is also imported from Brazil, the European Union, and Canada, making it one of the top food products that is sourced from outside the region. The United States dominates the market, accounting for nearly 80%; Brazil accounts for about 12%; and Canada and the EU account for less than 5% each (see Table 2).

Table 2 shows summary statistics for monthly poultry meat product imports into the CARICOM territories for the January 2002 to July 2014 period. These are based on data from the Global Trade Atlas for poultry products (broiler meat, turkey meat and meat from other birds) sourced from the United States, Brazil, Canada and the European Union. The US was the main supplier over the period, supplying the market with approximately 24 million pounds monthly on average, ranging from roughly 11 million pounds to 43 million pounds. Brazil, Canada and the EU supplied considerably less on average. Per expenditure shares of poultry meat consumed from the various exporting countries, the US dominated in this respect, accounting for 79% of CARICOM's import expenditure on poultry meat over the period on average. Brazil accounted for 12%, and the EU and Canada for roughly 5% and 3%, respectively, on average. The summary statistics reveal considerable range in CARICOM's import expenditures from the different source countries over the period, particularly for the US and Brazil. The European Union had the highest average unit value at $ 0.74 per pound, and the Canada the lowest at $0.42 per pound.

Table 2. Summary Statistics of CARICOM Countries Poultry Products Imports 2002-2014.

	Mean	**Std. Dev**	**Min**	**Max**
		Quantity (million pounds)		
European Union	0.806	0.491	0.066	3.463
Brazil	3.091	0.960	1.356	10.022
Canada	1.085	0.415	0.258	3.243
United States	23.685	8.484	10.942	42.509
		Unit Value ($/pound)		
European Union	0.74	0.20	0.32	1.12
Brazil	0.55	0.22	0.15	1.06
Canada	0.42	0.17	0.18	1.08
United States	0.46	0.08	0.29	0.59
		Expenditure Share		
European Union	4.92%	3.74%	0.46%	20.67%
Brazil	12.31%	4.34%	4.86%	42.97%
Canada	3.33%	1.30%	0.85%	7.44%
United States	79.44%	6.12%	46.29%	89.44%

Figures 1 through 4 show the mix of poultry products exported to CARICOM between 2002 and2013. With the exception of Canada, all other source countries supply mostly chicken meat to CARICOM, and other poultry meats to a far lesser extent. Canada's poultry meat exports to the region have comprised mostly turkey meat, although it has decreased in recent years while chicken meat imports have increased. Other poultry meat (ducks and geese) imports have been negligible over the time period shown.

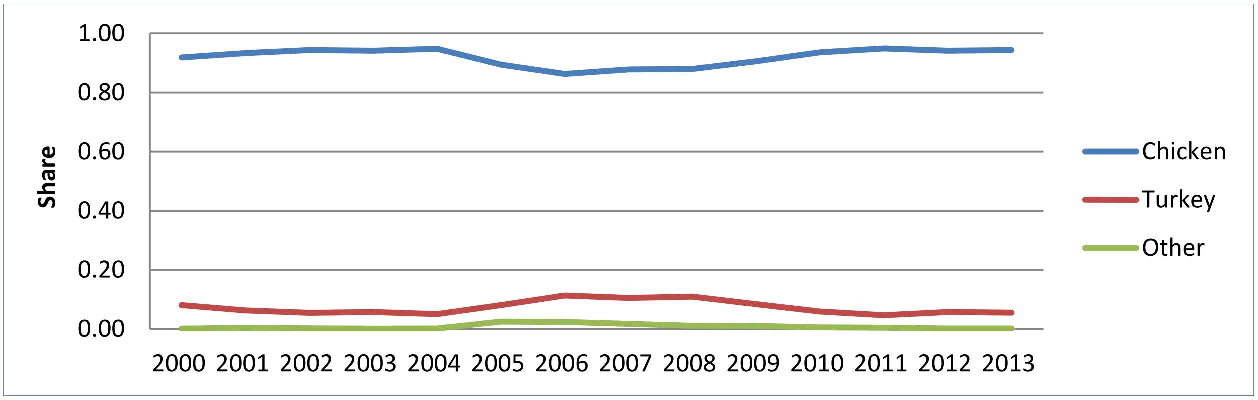

Figure 1. United States: Poultry meat exports to CARICOM by product share 2002-2013.
Source. Global Trade Atlas 2014.

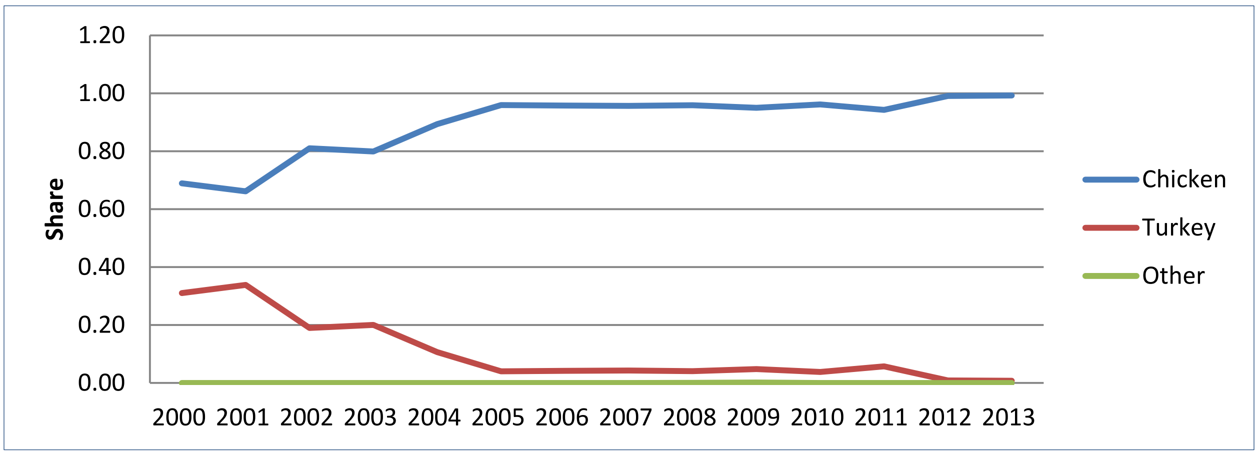

Figure 2. Brazil: Poultry meat exports to CARICOM by product share 2002-2013.
Source. Global Trade Atlas 2014.
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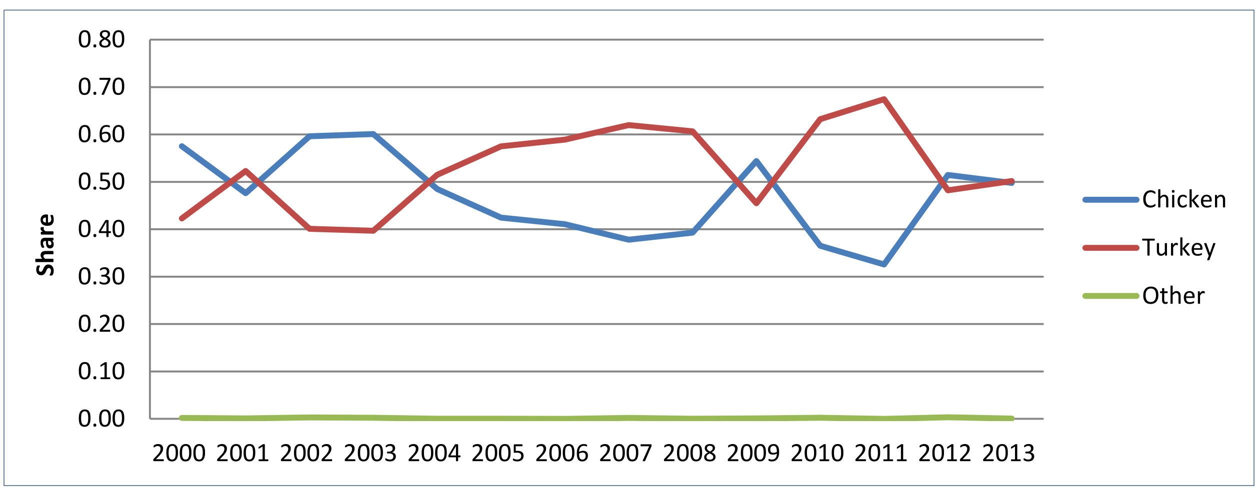

Figure 3. Canada: Poultry meat exports to CARICOM by product share 2002-2013
Source. Global Trade Atlas 2014.

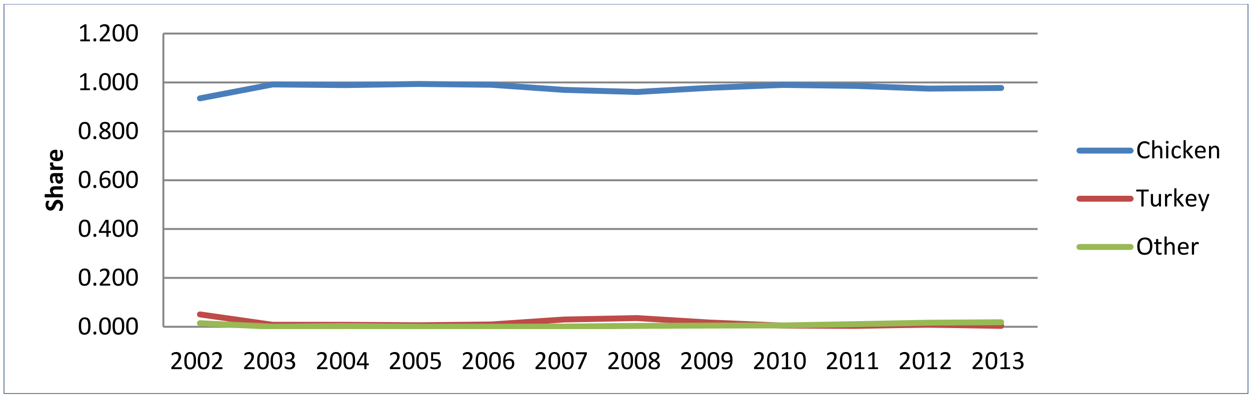

Figure 4. European Union: Poultry meat exports to CARICOM by product share 2002-2013.
Source. Global Trade Atlas 2014.

Key Issues Affecting the Caribbean Poultry Industry

The poultry industry is the largest agro-industrial enterprise across the region, with approximately US$650 million in sales annually (Agritrade 2011). Average annual production is estimated at 200,000 metric tons of meats, less than half of the total poultry meat consumed by the CARICOM community. Although most CARICOM countries engage in some domestic production, the bulk of production occurs in a few countries. Between 2004 and 2008, Jamaica, Trinidad and Tobago, Guyana, Barbados and Belize accounted for 90.3% of total output regionally, with individual contributions of 46%, 21.6%, 10.3%, 6.4% and 6%, respectively (Caribbean Agribusiness, 2014). The industry employs over 75, 000 persons throughout the region, and is the largest generator of small business and rural entrepreneurship, particularly for women (Agritrade 2011; FAO 2011). It plays a significant role in the promotion of food security throughout CARICOM (Caribbean Agribusiness 2014). The significance of these contributions signals why the industry continues to seek protected status despite ongoing trade liberalization efforts[2].

The industry faces myriad challenges relating to production that increase production costs and risks, and that place it at a competitive disadvantage relative to global competitors[3]. Feed costs comprise roughly 65% of the cost of producing broilers (Feed Info 2012). Aside from Belize, Guyana and Suriname, most countries lack the capacity to produce the raw materials that are typically used for feed and must import feedstocks; this dependency increases the sector's vulnerability to increasing global grain prices and unfavorable exchange rate movements (Agritrade 2012). In countries such as Barbados that manufacture poultry feed, costs for inputs such as fuel, electricity and water that are used in local feed manufacturing have reportedly increased in recent years (Barbados Advocate 2013). Caribbean governments have sought to mitigate these issues by launching initiatives to develop poultry feed supply chains within the region. Belize is self-sufficient in feed corn, and has supplied poultry operations in Jamaica and

[2] In fact, the poultry sector was excluded from tariff liberalization commitments under the Economic Partnership Agreement with the European Union (CRNM 2008; Agritrade 2013).
[3] The inability to compete with imports is a noted problem across many Caribbean industries, given that agricultural producers face major competitiveness constraints at all points of the food value chain (FAO 2013).

Guyana in recent years. Similar initiatives are being explored for Suriname and Guyana, which have the capacity for feed corn and soybean production. Pilot projects for feed production are also being evaluated in Trinidad and Tobago, Jamaica and Barbados (Agritrade 2011b; GFAR 2013). It would appear that regional self-sufficiency in poultry feed production is a major goal, as it may bolster the regional poultry industry and future expansion.

Additionally, the lack of mechanisms for food safety and production standards certification has adversely affected poultry meat trade between CARICOM member states, and between CARICOM and other countries. The Caribbean Poultry Association (CPA) argues that the lack of standards has permitted importation of low quality parts and barred entry of Caribbean poultry meat exports into certain markets (Agritrade 2011). As such, it has been lobbying for the development of appropriate legal and regulatory frameworks that could help with export certification, and for establishment of National Agricultural Health and Food Safety Agencies in member states. Such agencies would be charged with regulating imports and requiring that they meet SPS standards (Agritrade 2011).

The CPA has also actively pushed for other related measures including: (a) implementation of safeguard mechanisms linked to import licensing arrangements; (b) prohibitions on frozen products that are thawed and sold as fresh chilled products; (c) the introduction of country of origin labelling; (d) prohibitions on repackaging of imported frozen poultry parts; and (e) harmonization and strengthening of Caribbean SPS regulatory systems that apply to poultry products (Agritrade 2011). In 2012, the Caribbean Regional Standard for Poultry & Poultry Products was approved by the CARICOM Council for Trade and Economic Development (COTED). It specifies certain requirements relating to several of the aforementioned measures, and is seen as an important step toward removal of non-tariff barriers to poultry trade within the region (Agritrade 2013).

Tariffs are the main policy instruments that are used to protect the regional industry. Imports into CARICOM territories face a Common External Tariff (CET) and, in some cases, applicable surcharges are also applied. The CET is designed to protect trade sensitive domestic industries and provide a harmonized coding system and consistent tariff structure for importation of products from countries that are not members of CARICOM. The agricultural sector is accorded separate treatment[4] in the form of higher protection (40%) for imported commodities, whereas inputs are not subject to tariffs. Member states have broad scope for suspensions and reductions, as well as for national derogations from the CET as authorized by COTED via Article 83 of the Revised Treaty. In the CET Schedule (tariff heading 02.07), fresh, chilled or frozen poultry meat that is not cut in pieces is subject to the highest rate (40%).

Methodology and Data

The Central Bureau of Statistics (CBS) differential demand system derived by Keller and Van Driel (1985) is chosen to estimate Caribbean import demand parameters for poultry meat,

[4] Arguments that were advanced in support of tariff protection have been agriculture's role in employment creation, rural development, generation of foreign exchange earnings and the need for protection from dumping are arguments (ECLAC 1999).

differentiating by source (United States, Brazil, Canada, and the European Union). The CBS model combines attractive features from both the Almost Ideal Demand Systems (AIDS) model and the Rotterdam model: It includes the non-linear expenditure effects of the AIDS (Deaton and Muellbauer 1980) and the price effect of the Rotterdam model (Theil 1966; Barten 1969).

Following Kesvan et al. (1993) and Jones, Harvey, Hahn and Muhammad (2008), a dynamic specification of the general CBS model was used to capture both the short-run and long-run relationships in CARICOM countries' poultry products import demand, which can be written as:

$$(1) \quad w_{it} \cdot \left[\partial Lnq_i - \sum_j w_j \partial Lnq_j \right] = a_i + \sum c_{ij} \partial Lnp_{jt} + \sum d_{ij} \partial Lnp_{jt-1} + b_{i1} dBQ_t + b_{i2} dBQ_{t-1} + e_{it}$$

where w_{it} is the expenditure share of poultry products consumed from the i^{th} source country, p_j is the differential price based on the unit value of imports, a, c_{ij}, d_{ij}, b_1, and b_2 are parameters to be estimated, and e_{ij} is the disturbance term. The lagged quantity adds the dynamic element to the model. The source countries/regions included in the model are: United States, Brazil, Canada, and the European Union. Meat from broilers, turkeys and other birds were aggregated into one product denoted "poultry" primarily to eliminate the zeros for months when specific meats were not imported. The United States equation was omitted to avoid singularity. By construction, the endogenous variables of the CBS demand system sum to 0 in every time period, which makes the error terms sum to 0 also. To avoid singularity therefore, an equation is dropped in the estimation process and retrieved at the end of the process since the estimates will be invariant to the dropped equation. In order for the system of equations to be theoretically consistent, the following restrictions on the coefficients must hold:

$$(2) \quad \sum_i c_{ij} = \sum_j c_{ij} = \sum_i b_i = \sum_i a_i = 0,$$

$$(3) \quad c_{ij} = c_{ji}, \forall i, j$$

Equation 2 implies that the coefficients sum to zero when added over all the inputs and that the CBS model is homogeneous of degree 0, and consistent with the budget constraint. Equation 3 ensures that Slutsky symmetry conditions are satisfied. Own-price, cross-price, and expenditure elasticities, η are calculated for country-specific import demand:

$$(4) \quad \eta_{ij} = \frac{(c_{ij} - d_{ij} + w_i w_j) dLnp_j}{w_i} \quad \text{Own-price and cross-price elasticities}$$

$$(5) \quad \eta_{iy} = 1 + \frac{\beta_i}{w_i} \quad \text{Expenditure elasticity}$$

Data for this analysis was sourced from the Global Trade Atlas. The source countries are the United States, Brazil, Canada and the European Union. We would have liked to include domestic consumption of CARICOM produced poultry in the model to capture a total poultry product demand, but corresponding data on monthly consumption of domestic poultry products and prices were unavailable. Monthly quantities and values of poultry meat imported into the

CARICOM member states were obtained for the 2002-2014 period.[5] More than 99% of poultry meat imported by CARICOM countries came from the source countries modeled.

Results

Tables 3 through 7 report the results of our model. Tables 3 and 4 report the parameter estimates and matrix of AR-1 processes, respectively. Tables 5 and 6 report the estimated short run and long run elasticities for poultry products imported into CARICOM over the 2002-2014 period. The calculated cross price elasticities account for the substitution and expenditure effects of price. Positive cross price elasticities denote some degree of substitution between the poultry meat imports sourced by CARICOM from the various countries. For example, a cross-price elasticity of 0.503 for Canada with the EU implies that a 10% increase in the price of Canadian poultry meat would cause a 5% increase in poultry meat imports from the EU. A negative cross-price elasticity signals that the expenditure effects of a price change dominate pure substitution effects – as shown in the case of the US with all the other competitors in the CARICOM poultry meat market.

In both the short run and long run, calculated own price elasticities have the expected negative sign and are statistically significant. Own price elasticities for the EU, Canada and the United States were elastic, implying that an increase their poultry price would result in a more than proportionate decrease in the quantity of poultry products demanded from CARICOM countries. As for Brazil, an increase in its poultry price would result in a less than proportionate decrease in demand from CARICOM countries. Thus, any price reductions brought about by liberalized trade agreements could be expected to trigger greater than proportional changes in CARICOM's import demand for poultry meat from those source countries. The calculated results for Brazil show that it would be the exception in this case.

The results indicate that CARICOM countries are highly price responsive to poultry meat imports from the United States: the short run elasticity of -1.738 suggests that a 10% reduction in the import prices of US poultry meat products would increase CARICOM's demand for poultry meats by 17.38%. The long run elasticity shows that this would remain virtually unchanged in the long run. Per Canada and the EU, a 10% reduction in their import poultry meat prices would decrease import demand in CARICOM countries by 12.22% and 12.69%, respectively, in the short run. In a long run context, there is increased responsiveness to import price changes, particularly for poultry meat sourced from the EU. A 10% increase in import prices would reduce CARICOM import demand by almost 20%. Finally, Brazil has a statistically significant own price elasticities in both the short run (-0.709) and the long run (-0.990). These estimates point to an inelastic poultry meat demand relative to the other source countries, where a 10% increase in prices of poultry meat sourced from Brazil would have a less than proportional decrease in demand by CARICOM countries.

[5] Not all of the members listed are net importers of poultry meat; for example, Belize is self-sufficient in poultry meat. Associate members of CARICOM were also excluded from the model.

Table 3. CBS Model Parameter Estimates for CARICOM Poultry Meat Import Demand.

Parameter	Coefficient	Standard Error	t Value
a_1	0.000	0.001	0.08
b_1	-0.022	0.012	-1.86
C_1	-0.012	0.012	-1.01
g_{11}	-0.012	0.013	-0.89
g_{12}	-0.027	0.009	-3
g_{13}	0.017	0.007	2.67
g_{14}	0.042	0.027	1.54
h_{11}	-0.034	0.013	-2.69
h_{12}	0.021	0.009	2.35
h_{13}	-0.001	0.006	-0.23
h_{14}	-0.067	0.027	-2.49
a_2	0.000	0.002	-0.08
b_2	0.008	0.029	0.27
c_2	0.044	0.029	1.53
g_{22}	0.052	0.022	2.32
g_{23}	0.003	0.006	0.45
g_{24}	-0.086	0.065	-1.32
h_{22}	-0.029	0.022	-1.31
h_{23}	-0.003	0.006	-0.49
h_{24}	0.034	0.065	0.52
a_3	0.000	0.001	0.02
b_3	-0.021	0.009	-2.46
c_3	-0.018	0.008	-2.17
g_{33}	-0.007	0.006	-1.1
g_{34}	0.028	0.019	1.42
h_{33}	-0.004	0.006	-0.6
h_{34}	0.005	0.019	0.24

Table 4. Matrix of AR-1 Processes

	European Union	Brazil	Canada
European Union	-0.309	0.254	-0.014
	(0.085)	0.200)	(0.060)
Brazil	-0.031	-0.412	0.005
	(0.035)	(0.081)	(0.024)
Canada	0.002	-0.180	-0.469
	(0.111)	(0.266)	(0.079)

Table 5. Estimated Short Run Elasticities for CARICOM Poultry Products Import Demand

	European Union	Brazil	Canada	United States	Expenditure
European Union	**-1.269*****	-0.619***	0.335**	0.416	0.543**
	(0.272)	(0.189)	(0.132)	(0.541)	(0.245)
Brazil	-0.273***	**-0.709*****	-0.012	-1.541***	1.064***
	(0.074)	**(0.186)**	(0.052)	(0.519)	(0.234)
Canada	0.503***	0.042	**-1.222*****	0.538	0.365
	(0.196)	(0.196)	**(0.190)**	(0.572)	(0.258)
United States	-0.020	-0.152***	-0.049***	**-1.738*****	1.045***
	(0.022)	(0.032)	(0.014)	**(0.106)**	(0.042)

Note. Asymptotic standard errors are in brackets. ***<0.01, **<0.05, *<0.10.

Table 6. Estimated Long-Run Elasticities for CARICOM Poultry Products Import Demand

	European Union	Brazil	Canada	United States	Expenditure
European Union	**-1.956*****	-0.164	0.313	0.757	0.297
	(0.412)	(0.267)	(0.199)	(0.764)	(0.377)
Brazil	-0.121	**-0.990*****	-0.049	-1.551**	1.420***
	(0.106)	**(0.256)**	(0.071)	(0.699)	(0.351)
Canada	0.486*	0.017	**-1.319*****	1.116	-0.185
	(0.292)	(0.264)	**(0.281)**	(0.751)	(0.377)
United States	-0.002	-0.140***	-0.038**	**-1.715*****	1.092***
	(0.032)	(0.045)	(0.019)	**(0.144)**	(0.052)

Note. Asymptotic standard errors are in brackets. ***<0.01, **<0.05, *<0.10.

Short run and long run expenditure elasticities are also reported in Tables 5 and 6. They capture the degree to which the amount of poultry meat sourced from each supplying country changes when overall demand for poultry meat in CARICOM countries change. Brazil has the largest expenditure elasticities in the short run and the long run, 1.064 and 1.420, respectively. The interpretation here is that a 10% increase in overall poultry meat import demand by CARICOM would increase demand for Brazilian poultry meat imports by 10.64% in the short run, and by 14.20% in the long run, respectively.

Table 7 reports the overall impact of the CARICOM's Common External Tariff (CET) on import quantities sourced from the various countries. Short run and long run estimates of percentage changes in poultry meat imports into CARICOM show that Brazil and the US would benefit significantly from removal of the CET. In the short run, poultry imports from Brazil would increase by 129.5% and those from the US would increase 100%, over current imported quantities. Imports from Brazil into CARICOM would increase by an additional 9% in the long run, whereas the United States' poultry meat imports would dip slightly by 3.27% (to 96.8%) in the long run. In the long run, CARICOM importers would be able to reassess all import sources. Given an increased market price and decreased demand, importers may shift import composition to meet market demand, which implies that there could be changes in proportions sourced from the various exporting countries. Poultry meat imports sourced from the EU would increase by roughly 58% in the short run, and by 55% in the long run. Relative to the other source countries, poultry meat imports from Canada would increase the least (7.10%) in the short run if the CET were removed, and decrease by 15.3% in the long run.

Table 7. Overall Impact of the External Tariff on Import Quantity

	Removal of the External Tariff		Doubling of the External Tariff	
	Short-Run	Long-Run	Short-Run	Long-Run
European Union	58.08%	53.64%	-38.26%	-35.33%
Brazil	129.49%	138.48%	-85.30%	-91.22%
Canada	7.10%	-15.32%	-4.68%	10.09%
United States	100.07%	96.80%	-65.91%	-63.76%

Note. Current external tariff averages 40 percent.

Recent discussions between Caribbean poultry industry stakeholders and governments have focused mostly on maintaining tariff protection, with a tendency towards increasing it. An increase in the current rate to 80% has been suggested by the Caribbean Poultry Association on the grounds that it would permit domestically produced poultry meat to be more competitive in domestic markets. This informs our second scenario which evaluates the impact of a doubling of the CET from 40% to 80% on imported poultry meat from source countries. The underlying assumption is that the elasticities that are generated by the model takes the tariff into account in the CIF unit value of each country's poultry imports. Our short run results suggest that this would decrease import quantities from all source countries, with Brazil exhibiting the largest reduction (85.3%). The United States would have the second largest reduction (65.9%), and poultry meat sourced from the EU would decline by 38.3% in the short run. Meat sourced from Canada would only decrease by roughly 4.7% over current levels (in the short run). In a long run context however, poultry meats sourced from Canada are shown to increase despite a doubling of the CET. Given that Canada was shown to have the lowest average price for poultry products, and that all source countries face the same CET, the expenditure effect would outweigh the substitution effect with importers opting to expand poultry imports from the cheapest source. The largest long run impact is noted for Brazil, in that poultry meats sourced from that country would continue to decline (91%). In the long run, imported poultry meat from the US would decline approximately 64%.

Discussion

Owing to data limitations, CARICOM's domestic demand for domestically produced poultry meat is unaccounted for in this model, and its substitution effects that could have arisen under the two CET scenarios cannot be directly assessed. However, had this assessment been possible and demand for domestically produced poultry were found to be inelastic, then regional producers would gain higher revenues with increased market prices. In a small country context however, the regional producers would essentially be price takers and exert no influence over market prices. Bearing in mind that CARICOM poultry producers have little control over the cost of production, margins can only be increased through increased revenues. Maintaining the CET serves to increase poultry meat prices in the CARICOM market in general, leading to increased revenues for regional producers since prices are elevated over what would typically be observed.

Although our model did not calculate welfare effects of the various scenarios, several potential impacts can be discussed nonetheless. In the light of an elastic demand for poultry meat imports, increased poultry prices stemming from an increased CET would cause imports to decrease. While some trade diversion may occur, it does not necessarily follow that regional producers would be able to adequately meet any deficits in the domestic market – and essentially utilize the displaced trade. Additionally, an increase in tariff rates on poultry meat imports may also serve to keep marginal producers in the regional industry, whereas if the rates were decreased or eliminated altogether, only efficient producers would remain in business. As per CARICOM poultry meat consumers, an increased CET could be expected to adversely impact consumer surplus given increased poultry meat prices.

Our results suggest that an expansion or a removal of the CET creates some substitution and diversion of trade. The source countries each export different proportions of various poultry meats to CARICOM. Poultry imports increase following removal of the tariff, but clearly not all source countries benefit from the same proportional increase in imports (Table 7). Our results show that highly efficient producers, such as Brazil and the United States benefit significantly, which is expected.

Conclusions

The major objective of this paper was to estimate CARICOM import demand parameters for poultry meat products, taking into account the different countries that compete in the regional market. The own price elasticities reveal that Caribbean poultry import demand is highly price responsive in both the short run and the long run. Any significant increases in imported poultry prices could be expected to trigger greater than proportional decreases in quantities demanded from the United States, Canada and the European Union. Brazil was the sole exception in this regard, where an inelastic demand for poultry meat imports into the Caribbean was noted. These findings were also apparent in the long run, and with an increased responsiveness to price changes, except in the case of the US. The price sensitivity noted in relation to several of the source countries would seem to imply that those that offer the most competitive prices could garner larger shares of the market.

A secondary objective of our paper was to gauge how poultry meat imports into CARICOM countries would change under two scenarios: (a) removal of the CET and (b) doubling of the CET to 80%. Given our findings, the implications for source countries, and for producers and consumers in the Caribbean region are of interest. Although these can be discussed in general terms, an important caveat is that our model does not calculate welfare effects of changes in CARICOM's tariff policy. The scenarios evaluating removal and an increase in the CET rates show that if either were implemented as policy, poultry meat trade would be affected. Complete removal of the CET would clearly impact countries that export poultry meat to the Caribbean (US, EU, Brazil and Canada), and these countries would be able to expand on poultry meat exports in the long run. The results for Canada show the opposite effect, possibly indicating that the other source countries would be better able to compete in the Caribbean market. Caribbean consumers of poultry meats would likely benefit from CET removal as it would result in lower prices for imported poultry meat and products. The likely losers from this scenario would be Caribbean poultry producers; our results suggest that imports would dramatically increase, particularly from the two largest global competitors – the US and Brazil. Caribbean poultry producers currently face myriad problems stemming from high production costs and risks, and are unable to efficiently compete in domestic and international markets. CET removal could likely adversely affect the regional poultry industry, which would be hard pressed to respond competitively due to existing constraints.

The alternative case – a doubling of the CET to 80% – could benefit Caribbean poultry producers given that poultry meat imports would decline significantly, and from Brazil and the US in particular. Exports from source countries would decline, and Caribbean consumers would face higher prices on imported poultry meat. As noted in the previous section however, that poultry imports would decrease does not mean that Caribbean producers would be able to respond and meet any deficits. The adverse effects could be disconcerting for Caribbean consumers of poultry, especially if producers are unable to meet domestic demand. Poultry meat – broiler meat in particular – is the most widely consumed meat and the major protein source in the region. In sum, whether CARICOM member states choose to increase the CET on poultry imports or completely remove it, there may be important ramifications for exporting countries, and for stakeholders in the Caribbean poultry industry and for Caribbean consumers. Indeed, how to reconcile growing consumer demand for low-cost protein with local poultry producers' lobbying for tariff protection will likely remain a key challenge for the regional poultry industry and policymakers alike.

In closing, despite its contribution to the literature, this study specifies one model, assumes one functional form and utilizes one data set. Therefore, our results should be viewed as preliminary. Future research on this topic, and that specifically addresses the welfare effects of CET changes, could therefore be instructive.

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International Food and Agribusiness Management Review
Volume 18 Special Issue A, 2015

Brazil's Broiler Industry: Increasing Efficiency and Trade[1]

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Abstract

Brazil's broiler industry growth over the past fifteen years has led the country to become one of the world's leaders in the industry. Between 1999 and 2014 Brazil's broiler production increased from 5.5 million tons to 12.7 million tons, or 130 percent, propelling the country to become the world's third largest producer after the United States and China. Exports have increased fivefold since 1999 with Brazil, in recent years, overtaking the United States as the world's largest chicken meat exporter. The very rapid and successful vertical integration in the poultry industry in Brazil has led to productivity growth, efficiency gains from vertical coordination, and lower production costs. We examine the costs, returns, and profitability of commercial broiler production in Brazil taking into account the country's regional diversity in production, the size of operations, and the type of technology used.

Keywords: Brazil, broilers, production, technical efficiency, trade

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[1] The views expressed here are those of the authors, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

Introduction

Over the past 15 years Brazil has evolved into the world's largest exporter of broiler meat, the world's 3rd broiler producer, and an important meat competitor of the United States. In 2000 chicken meat accounted for 42 percent of Brazil's animal protein sector, producing 6 million tons of broiler meat. Chicken meat production increased 5.2 percent per year during 2000-2014 to reach 13 million tons in 2014 (USDA/FASa). Since 2004 (with the exception of 2013 when U.S. broiler exports were larger), Brazil has been ranked as the world's largest broiler exporter, ahead of the United States, the European Union, China, and Thailand. In 2014, Brazilian broiler exports reached over 3.6 million tons, equivalent to 34 percent of the global broiler trade (USDA/FASa). Brazil's domestic chicken meat consumption is also significant, as 72 percent of total production is consumed in the domestic market. Favorable price relationships between chicken meat and competing meats (beef, pork) have contributed to gains in broiler meat competitiveness.

Brazil's broiler industry is characterized by large-scale production, high technology use, and integration contracts covering about 85 percent of broiler production (Caldas 2014). These changes have resulted in further reductions in production costs, greater efficiency, and increased exports. Various factors have contributed to the development of large poultry operations in Brazil including low labor costs, ample feed availability, favorable foreign investment regulations, and a large domestic market. Government policies have also facilitated sector growth with the provision of subsidized credit for production and investment and support to the feed sector (CONAB 2014). A better understanding of Brazil's broiler industry, especially of costs at farm level, of technical performance for broiler production, and of the importance of emerging new poultry production regions in Brazil could provide an indication of the industry's future competitiveness.

Growth and Efficiency in the Broiler Industry

Recent studies on the broiler industry in various countries around the world, including the United States (MacDonald 2014; Miles et al. 2012), Thailand (Areerat et al. 2012), and Nigeria (Bamiro et al. 2009) have sought to identify the factors driving the industry's growth, with a focus on contract growers. These studies examined the relationship between the industry organization and the financial performance of broiler grow-out operations, concluding that, while the system of vertical integration organization had fueled the industry's growth, other factors (i.e., production practices, size of operations, and technology), had been crucial for continuing gains in the industry's productivity and profitability.

Other studies have found that improvements in on-farm production practices (e.g. floor space, feeder space per bird) constitute very significant cost-reducing drivers in per-broiler feed, labor, and housing requirements (Dos Santos et. al. 1998). Expanded production has been found to allow integrators to realize further costs saving through scale economies in larger facilities (Sandi et. al. 2011). More recent studies have focused on improvements in broiler housing as a crucial contribution to bird health and industry productivity. When exposed to heat stress by high temperatures, the bird present decreased feed intake and consequently, a reduction in weight gain; technologies associated with climate controls and ventilation systems contribute to better bird health, reduced bird mortality, and improved feed conversion (MacDonald 2014).

For the case of Brazil, several studies of the efficiency of the poultry industries have been conducted both at the national level (Siffert and Faveret 1999), and regional levels (Mendes et al. 2014). Both approaches concluded that the adoption of advanced ventilation systems to manage temperatures is the most crucial factor to raising productivity by improving efficiency. Various researchers have analyzed the issue of agricultural productivity improvements measuring agricultural production and farms' efficiency as a means to finding alternative ways to improve the utilization of resources (Kamruzzaman et al. 2007; Coelli et al. 2002), and while most have focused on major food crops like rice and wheat, a few others have focused on poultry and broiler meat farms (Areerat et al. 2012; Begum et al. 2010).

Brazil's Broiler Production Systems

In Brazil, broiler production and processing is carried out under a system of tightly integrated production contracts operated by integrator firms, with independent chick growers. In Brazil, eight integrators account for 55 percent of broiler production, while the top four integrators account for 38 percent of production (EMBRAPA 2014). Under the system of production contracts, integrators provide growers with chicks, feed, vaccine, and veterinary/technical assistance. Growers provide housing, labor, and utilities and grow the chicks to market weights. Much like in the United States, Brazilian chick growers, who have exclusive contracts with integrators, receive payment for the services that they provide, with premiums and discounts tied to the efficiency with which feed is converted to live-weight broiler production (Caldas 2014).

Although broiler production occurs in all regions of Brazil, over three-fourths of broiler production is concentrated in the South and Southeast regions (Figure 1). In 2014, Paraná and São Paulo accounted for 22 percent and 17 percent, respectively of total broiler production (IBGE 2014). The integration system model was initiated in São Paulo State in the early 1960s and expanded to the South region (Paraná, Santa Catarina, and Rio Grande do Sul) in the 1970s where the feed availability, a large urban population, and the proximity to ports favored the development of broiler operations (EMBRAPA 2014). The South region now accounts for 56 percent of broiler production (IBGE 2014). Government subsidized credit for investments in the broiler sector, and technical assistance provided by the poultry industries, further contributed to the development of the broiler integration system in Brazil (EMBRAPA 2014).

Two decades later the accelerated westward expansion of agriculture to Brazil's Center-West region (Goias, Mato Grosso, and Mato Grosso do Sul) benefited primarily corn and soybean production. These benefits also extended to broiler (and hogs) operations, since close to 90 percent of Brazilian poultry feed is composed of corn (70 percent) and soymeal (20 percent). The development of commercial broiler production in the Center-West was initiated during the early 1990s when several major international companies sponsored the migration of the broiler (and pork) industries from the South to the Center-West region following the feed availability and with production targeted almost exclusively for international markets (De Jesus et al. 2007).

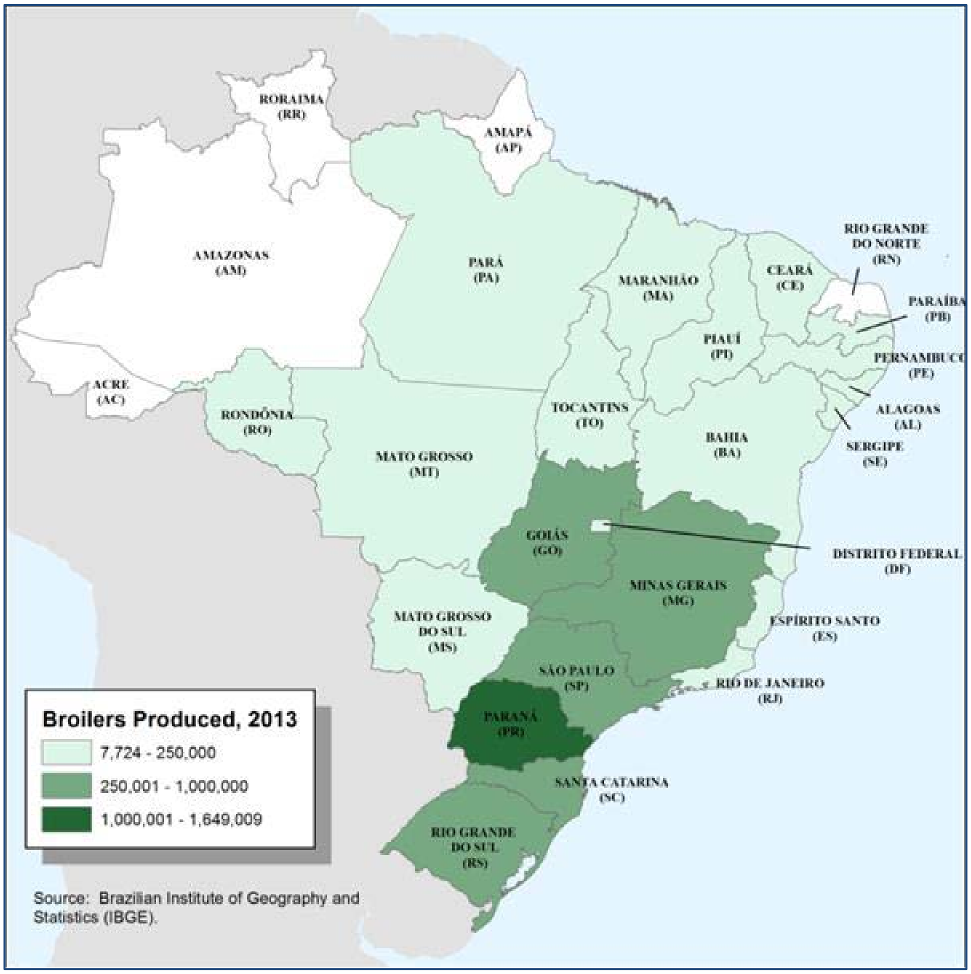

Figure 1. Brazil's Broiler Production by State

Our analysis seeks to identify the industry's productive structure, net returns, and characteristics of broiler operations in Brazil. To analyze Brazilian broiler operations characteristics and investigate technical efficiency of these operations, we use monthly cost of production survey data of 1,440 poultry operations as reported by Brazil's National Supply Company (*Companhia Nacional de Abastecimento*, CONAB) and the Brazilian Corporation for Agricultural Research (*Empresa Brasileira de Pesquisa Agropecuária*, EMBRAPA).

Carried out in the most important broiler producing areas in Brazil, the survey provides monthly information on costs, flock size, feed conversion, and types of climate technology in use during 2007-2010. The data includes labor expenses, feed costs, chick costs, bedding, antibiotics, technical assistance, and transportation. The survey separates costs for growers and integrators for broiler operations across ten important poultry-producing Brazilian States: Ceará, Goias, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná, Pernambuco, Santa Catarina, São Paulo, and Rio Grande do Sul.

It is generally recognized that the adoption of ventilation technologies on farms have implications for feed conversion and a faster grow-out time to maturity (MacDonald 2014). Given the extreme sensitivity of the flock to heat conditions we take into consideration technology levels with different types of ventilation systems used to manage temperatures:

Climate Control Ventilation Technology *(Climatizado)*, Conventional Ventilation Technology *(Automático)*, and Manual Ventilation Technology *(Manual).* To examine Brazil's broiler production's overall efficiency and measure its competitiveness we use a stochastic frontier analysis (SFA) parametric method to measure technical efficiency associated with technology across different operation sizes and regions within Brazil.

Table 1 presents the balance sheet of broiler operations by region, revealing the heterogeneity in operations in Brazil. Revenues generated by the broiler enterprise and costs vary by location, and as a result net returns (the difference between revenues/gross value of production and total costs) vary widely. More detailed analysis of individual balance sheets of revenue and cost by size of operation reveal that the most profitable operations of the broiler industry are located in the Southeast and Center-West regions where larger contract operations generate better financial returns. Profitability increases with size: as operations become more intensive in raising broilers for meat they are more profitable, as is the case for Mato Grosso and for Paraná.

Table 1. Balance Sheet of Production and Costs of Broiler Operations by Region, 2010[1]

Region	Revenue	Labor Expenses	Variable Expenses	Feed	Chicks	Fixed Costs	Other Expenses	Total Cost	Returns[2]
Center-West	50,878	738	2,359	22,022	5,004	1,724	1,620	34,061	16,817
South	31,253	793	2,175	18,219	4,376	1,342	1,395	28,832	2,421
Southeast	41,501	812	1,836	14,160	4,319	752	1,283	24,205	17,296
Northeast	52,422	1,045	3,218	28,711	6,708	1,489	1,718	44,372	8,050

Notes. [1]Calculated in $ USD; [2] Above Total Cost.
Source. CONAB/EMBRAPA, Cost of Production Survey, 2010

Cost of production survey data indicates that in 2010 only a percentage of the broiler farms had positive net returns and were able to cover all costs, including costs of capital recovery. With size classes based on production per flock, poultry operations with at least 25,000 birds had net returns of $1.06 per bird while farms with less than 19,000 birds had net returns of $0.32 (Table 2). Larger broiler operations have substantial integrator costs advantages, particularly in feed, the dominant cost in the production of poultry meat. The largest broiler operations are located in Minas Gerais, which accounts for just seven percent of production. As Minas Gerais is an important corn producing State, broiler operations in this State had feed costs 16 percent below feed costs of the three smaller classes and were also able to realize economies of scale on housing facilities. Costs were much higher for smaller broiler operations, with less than 19,000 birds. About 43 percent of smaller operations are located in Pernambuco and Ceará, and nearly one-third have less than 5,000 birds.

Profitable broiler operations were more common among large farms in 2010. Estimates of net returns from CONAB's surveys are based on regional averages but there is variation around average performance in the broiler farms within each class size. For example, farms with less than 19,000 birds had average net returns of $0.32 per bird in 2010, but for only 36 percent of them realized positive net returns with the gross value of production exceeding total costs and less than half of the farms were able to cover the opportunity costs of capital and farmer's labor. Forty-four percent of farms with 19,000 - 20,999 birds earned positive net returns, as did 43 percent of farms in the 21,000 - 24,999 class (Figure 2).

Table 2. Broilers Grower and Integrator Costs of Production by Enterprise Size, 2010

	< 19,000	19,000 - 20,999	21,000 - 24,999	> 25,000
Mean Broiler Farm Size (Number of Birds)	14,960	19,400	22,313	26,000
Output (kg)	37,537	50,050	57,731	61100
Total operating costs[1]	**2.23**	**1.90**	**1.93**	**1.09**
Purchased feed	1.50	1.26	1.31	0.66
Labor	0.06	0.05	0.04	0.05
Bedding materials	0.03	0.02	0.02	0.02
Technical assistance	0.01	0.01	0.02	0.05
Chicks	1.50	1.26	1.31	0.66
Transportation costs	0.09	0.07	0.05	0.02
Total costs	**2.34**	**2.01**	**2.04**	**1.13**
Gross value of production	2.66	2.94	2.74	2.19
Net returns	0.32	0.94	0.70	1.06

Note: [1]All costs are calculated in $ USD per broiler.
Source. USDA-Economic Research Service Using Data from Cost of Production Survey, CONAB.

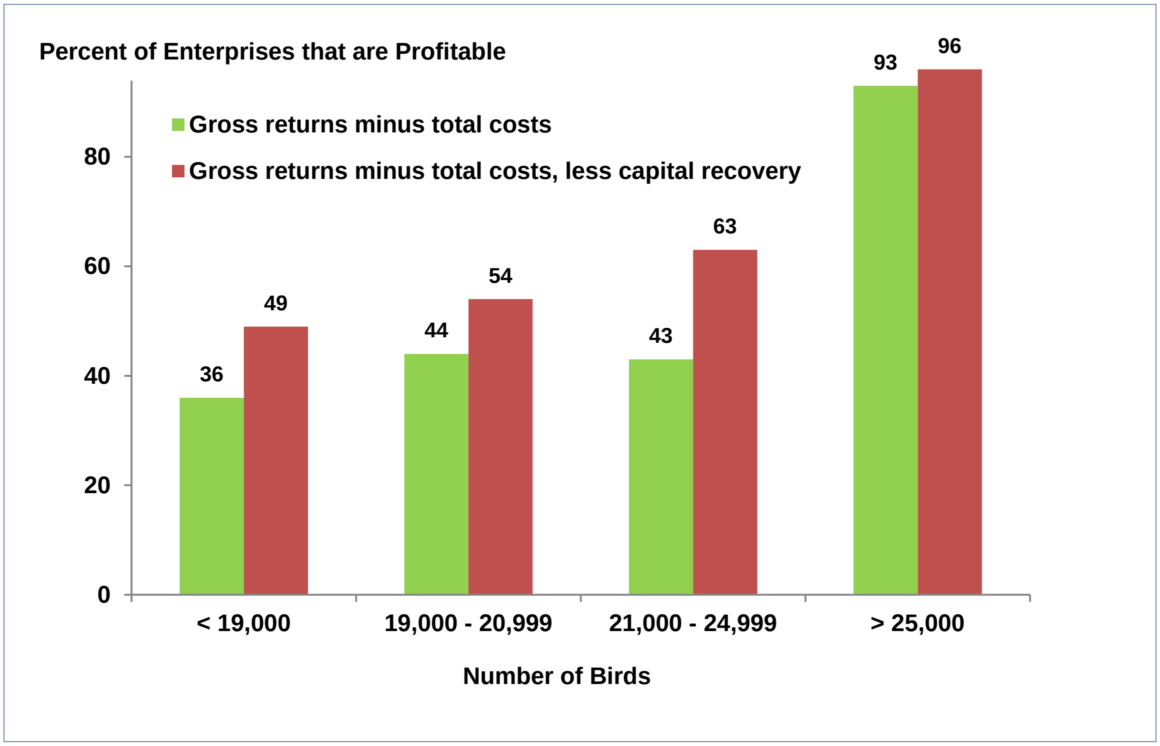

Figure 2. Profitable Broiler Enterprises in Brazil, by Size Class in 2010
Source. USDA-Economic Research Service Using Data from EMBRAPA, 2010.

Estimating Method

The stochastic frontier production function approach is used in this study for measuring technical efficiency while accounting for resource costs. Stochastic frontier modeling is often used to compare firms' relative efficiencies though it can also be used to derive estimates of productivity change over time. The technique has a number of benefits when compared to standard econometric estimation (OLS) of production functions. It estimates a 'true' production frontier rather than an average frontier, thus it fully represents the maximal properties of the production function. A stochastic frontier production function was first proposed by Aigner, Lovell and Schmidt (1977). The model takes the form:

$$\ln(y_i) = F(x_i : \beta) + v_i - u_i, i = 1,...N$$

where y_i is the output of the ith firm, x_i is a vector of inputs for the ith firm, β is a vector of parameters to be estimated, v_i a symmetric error term, and u_i a non-negative error term representing inefficiency.

We estimate a Cobb-Douglas function to analyze technical efficiency in 2007-2010 and model the inefficiency term with the Battese-Coelli (1995) model, which allows the inefficiency term to change over time to indicate some significant differences after 2007. Observations with missing data were dropped, giving us different number of observations by region.

The analysis identifies technical efficiency by climate control technology and by region within the country. Broiler grow-out data from CONAB and EMBRAPA used in the analysis include variables in the production function: labor, bedding, feed, chicks, antibiotics, transportation, and feed conversion; the dependent variable being the value of output. Technical assistance, flock size, and livestock credit are included in the inefficiency part of the model.

Results

The regression analysis reveals that the coefficients associated with labor, feed, chicks, and feed conversion are all positive as would be expected. All are significant at the 1 percent level. An increase in the quantity of feed consumed by the birds, labor used, and other inputs will cause increases in the output. The large elasticity for the use of feed reflects the importance of obtaining economies of scale in production. The sum of the elasticities for all inputs equals more than unity indicating increasing returns to scale. The feed conversion rate reflects the sensitivity of broiler production to increases in feed prices and highlights the importance of larger volume of feed purchases to reduce transaction costs.

With respect to transportation costs, the coefficient is negative, implying that an increase in transportation costs and longer distances to markets, negatively affects output. Antibiotics used to treat disease in animals, and which are sometimes provided routinely to birds in feed or water to prevent disease and to improve feed conversion, are not significant. In the inefficiency model, the variables explaining inefficiency include the size of the flock and access to resources such as technical support and credit. The coefficients for flock size and technical assistance are both negative, as expected. Large flock size significantly reduces inefficiency as it helps derive economies of scale in feed purchases and output sales while access to technical assistance does not have a significant effect on inefficiency. Access to credit should increase the ability to use better quality inputs and services however results indicate that it was significantly less efficient.

Table 3. Parameter Estimates

Parameter	Estimated Value	Standard Error
Production Factors		
Labor	0.065***	(0.020)
Feed	0.774***	(0.028)
Chicks	0.061***	(0.022)
Antibiotics	-0.018	(0.012)
Transportation	-0.022*	(0.012)
Feed conversion	1.568***	(0.258)
Inefficiency Factors		
Technical assistance	-0.154	(0.100)
Flock size	-3.521***	(0.401)
Subsidized credit	0.592***	(0.137)

Note: * = significant at the 10% level, ** = significant at the 5% level, *** = significant at the 1% level
Source. Cost Data from CONAB/EMBRAPA Surveys.

Technical efficiency refers to the achievement of maximum potential output from a given quantity of input, given the available technology (Coelli et al. 1996). While efficient farms are those operating on the production frontier, inefficient farms are those operating below the production frontier. The average overall efficiency estimate for all 1,314 broiler operations which reported cost of production data is 0.924, indicating a high level of efficiency, but that farms have potential to reduce costs to increase efficiency. Estimates of the efficiency performance (TE) indicator by technology and by region are presented in Table 4 and Table 5.

The TE measures suggest that broiler enterprises have a greater potential to reduce costs by moving to a scale-efficient point. The efficiency or performance measures according to the type of ventilation technology used revealed that broiler enterprises using Climate Control technology are more efficient (0.943 on average) while broiler enterprises using Manual Control technology have the lowest scores (0.902 on average) and highest costs.

Table 4. Efficiency Estimation by Type of Technology Used

Technology	Efficiency (TE)
All farms	0.924
Climate Control	0.943
Conventional	0.927
Manual	0.902

Source. Model Results

An empirical assessment of broiler production also found that Climate Control technology yields higher productivity than other ventilation technologies in use (Caldas 2014). Another study computing technology coefficients for mortality rates, feed conversion, and bird weight gain across all three technologies also found that Climate Control technology outperforms the two other systems and is associated with bird housing capacity 52 and 64 percent higher than Conventional and Manual technology (Dos Santos et al. 1998).

On a regional basis, the detailed State-level results reveal that differences across regions reflect the differences between the modern and the more traditional segments of the broiler production sub-sector. Broiler enterprises in the Center-West States (Mato Grosso, Mato Grosso do Sul, Goias) report high overall efficiency ranging from 0.953 to 0.957. In the Center-West region, the efficiency indicators reflect high input intensity and high feed conversion efficiency.

Broiler enterprises in São Paulo, historically Brazil's leading agricultural State, are very efficient at 0.931, indicating high performance, despite the larger influence of labor costs in grower's total costs in São Paulo. A major factor responsible for this high level of efficiency in São Paulo is feed availability, as corn covers more area -25 percent of the State's cropland in 2007-2010- than any other crop in São Paulo. Feed costs in São Paulo and Mato Grosso are 7 percent lower compared to other States with feed costs totaling two-thirds of total costs (EMBRAPA 2014).

Broiler enterprises in Pernambuco and Ceará in the Northeast, where small and medium producers predominate have the lowest overall efficiency at 0.884 and 0.885, respectively. Given their increased dependence on government supplied feed, it might be relevant to investigate the impact of the timely delivery of such inputs on increased efficiency. The Southern region (Rio Grande do Sul, Paraná and Santa Catarina), has overall efficiency ranging from 0.886 to 0.893. In the South and Southern regions labor costs represent a larger share of grower's costs, compared to other States, but they receive the bulk of the government subsidized credit. In 2010, three-fourths of the credit, which helps reduce inefficiency, was allocated to broiler producers in São Paulo, Rio Grande do Sul, Paraná and Santa Catarina (Banco Central 2010).

Table 5. Efficiency Estimation by Region

	Farms	Efficiency (TE)
All Farms	1,314	0.924
Rio Grande do Sul	144	0.886
Santa Catarina	144	0.893
Paraná	144	0.889
Pernambuco	144	0.884
Ceará	144	0.885
São Paulo	99	0.931
Minas Gerais	108	0.956
Mato Grosso	99	0.953
Mato Grosso do Sul	144	0.957
Goias	144	0.955

Source. Model Results

Conclusions

Brazil's share of the global poultry meat market is significant and this share has been increasing rapidly over the past decade. With significant growth in domestic broiler meat demand -Brazil is the world's fourth-largest consumer market with over 9.4 million tons consumed in 2013- exports have increased at a much faster pace, making this country the largest exporter of broiler meat. Given the country's large feedstuffs production (corn, soybeans), Brazil is also able to keep the costs of feed rations low. Brazil's future productivity and efficiency gains in the broiler industry will have implications for global meats trade.

The Brazilian broiler industry is characterized by high productivity and high technology use. Technology advancements, low labor costs, and a large domestic market have encouraged the development of large broiler processing operations. We examined the structure of broiler production in Brazil and measure its efficiency using a stochastic frontier production function. Producer's survey data of 1,314 broiler farms collected in 2007-2010 was used to identify the distributional characteristics and the production profile of broiler operations in Brazil by region, type, and size.

After analyzing the structure of production costs directly from the survey data and estimating the overall efficiency and scale economies of broiler operations in the sample, we can conclude that the overall efficiency estimate, using all 1,314 operations for which data was available, is 0.924, indicating high overall efficiency. The analysis also found that there are economies of scale in production and that medium and large broiler operations are most cost effective and smaller poultry operations are least competitive. The efficiency or performance measures according to the type of ventilation technology indicate that broiler operations using the Climate Control technology are more efficient (0.943 on average) while broiler operations using Manual Control technology have the lowest scores (0.902 on average).

The results of frontier production function estimates indicates that there are differences in the average level of efficiency between the four regions and across States reflecting how large and medium broiler operations are more cost effective, and smaller broiler enterprises are least efficient. Our results indicate that the most integrated operations in the Center-West and Southeast are most efficient, with lower per-unit costs. Thus, broiler enterprises in these regions might reap the benefits of an expanded domestic and export demand-led market. Active support to growers such as technical assistance greatly contributes to get them to be more competitive. In Pernambuco and Ceará where broiler operations are least efficient, technical assistance represents less that 1 percent of total integrator's costs and equivalent to less than half the expenditures on technical assistance in Mato Grosso and Goias.

What is the situation for Brazil regarding the world broiler market? Brazil's broiler meat exports are expected to continue to account for a large share of the global meats market over the next decade, to represent nearly 41 percent of global broiler trade (USDA/OCE/WAOB 2014). Over the medium term to long term, broiler production is projected to increase 3.2 percent per year in 2015-2024 to reach nearly 19 million tons in 2024, in response to continued domestic and export demand-led growth (USDA/OCE/WAOB 2014).

Brazil's broiler industry future competitive position will depend not only on macroeconomic factors including volatility of the exchange rate and domestic and foreign income growth, but more importantly on the level of efficiency of individual broiler operations. Various factors including labor and feed availability, access to technical assistance, and access to credit significantly influence the level of efficiency of individual broiler operations. Policy and institutional arrangements that address these factors will lead to improved overall efficiency of an industry that remains as a benchmark due to the technical efficiency and technological advances attained in selected regions of the country.

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