The Effect of HPAI on ECOWAS Meat prices Using Price Transmission Analysis

By

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Selected Paper prepared for presentation at the 2016 Agricultural and Applied Economics Association Annual Meetings, , Boston, Massachusetts, July 31-August 2

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Abstract

This paper assesses impacts of Highly Pathogenic Avian Influenza (HPAI) outbreaks on meat prices in the Economic Community of West African States (ECOWAS). It analyzes price-transmission, applying innovative techniques, spatial models and a temporal dynamic structural model using VAR analysis coupled with impulse response functions (IRF's), to assess the magnitude of shocks on meat prices and length of time over which their effects persist.

Results find that the shock of HPAI outbreaks had a stronger negative impact on ECOWAS poultry prices than on the international prices, but weaker positive impact on ECOWAS beef and pork prices than on international prices. Poultry in ECOWAS was perfectly segmented during the pre-HPAI, but became more integrated post-HPAI, due to rising import demand for poultry evidenced by an average of 23 percent per year in the post-HPAI years 2009-2012.

Block-exogeneity-Wald tests indicated weak connectivity of international markets to ECOWAS poultry markets and strong connectivity of ECOWAS to the international markets. This means that if international prices of poultry are high (low), we can predict high (low) prices in ECOWAS, ceteris paribus, while prices in international markets do not follow ECOWAS prices, being a small market. There is strong connectivity between international and ECOWAS beef and pork prices, but weak relationships between ECOWAS prices and international markets. Linkages in both directions are significant for sheep and goat prices. Inference from Impulse Response Functions indicated that speed recovery from price shocks in international markets are faster than in ECOWAS.

[JEL Classification: Q110, Q130].

Key words: HPAI-impacts on ECOWAS meat imports, price transmission elasticity, integration/ segregation in ECOWAS meat markets, exchange rate impacts, connectivity of ECOWAS-international meat markets, Impulse Response Functions (IRFs).

Introduction

ECOWAS experienced a remarkable setback in poultry supplies during the 2003-2009 that was accompanied by rising import shares of beef, pork and sheep and goat (Figures 1 and 2). These changes were mainly caused by the outbreaks of the Highly Pathogenic Avian Influenza (HPAI) (H5N1). Global HPAI-outbreaks started 2003 in East-Asia and spread to other Asian countries, Siberia, Central Europe, the Middle East, Africa, and Western Europe (Avian Influenza, 2006). It was first reported in Northern Nigeria in February 2006, (Cecchi, G., et.al, 2008), then spread to other ECOWAS countries, including Burkina Faso, Niger, Ghana and Cote D'Ivoire, before was finally cleared in 2009. During this time, ECOWAS poultry production, consumption and imports dropped sharply, due to consumers' fear and governments import bans imposed on infected countries. However, after the outbreak consumers' fears subsided and demand for poultry rose. Domestic supplies were inadequate to meet this demand and poultry imports accelerated at an average annual rate of 23 percent during 2010-2012 and continued thereafter.

The analysis used price transmission process to explore connectivity to international meat markets and the speed of recovery in price changes in ECOWAS domestic markets in the pre-HPAI period (January 1999 to October 2005) and the post HPAI period (March 2009-December 2014). Price linkages relating ECOWAS to international markets play a vital role in the design of governmental appropriate policy measures to cope with meat price fluctuations, market stabilization, and national food security planning.

ECOWAS countries are gaining importance of all Sub-Saharan African countries after posting the highest Gross Domestic Production (GDP) growth rate of 3.46 percent (real) compared to 1.94 for all Sub-Saharan-Countries in 2014 (USDA-ERS-International Macroeconomic data set, October 2015).

This paper starts with a literature review, followed by derivation of the data structure and their constraints, the derivation of spatial price transmission models, dynamic models, empirical results, and concluding remarks.

Literature Review

Price linkages of major commodities focus on how prices are transmitted in related markets of the supply chain vertically and horizontally. Vertical price studies focus mainly on the links between farm, wholesale, and retail prices, while horizontal price linkage (also called spatial price linkages) are directly related to market integration between countries, or different regions within a country.

Trade integration[3] intuitively means a commodity is traded between two markets, and is basically built on price-based notion. The concept "tradability" is usually used when a commodity is traded between two countries. If a commodity is traded between two countries (or traders are indifferent to trade it), the commodity is classified as tradable and the two markets are called integrated. Thus, nonzero trade provides *prima facie* evidence of market integration and zero trade indicates *prima facie* evidence of market segregation. Theoretically however, positive trade flows are seen sufficient, but not necessary condition to establish trade. Barrett (2001) pointed out the need to distinguish between two notions within the Law of One Price (LOP) equilibrium: flow-based notion (tradability) and price-based notion (efficiency), recommending the later notion because it provides more detailed analysis on whether the pattern of trade is efficient, economically, socially or both, and also is more appealing to policy makers and business executives. Goodwin and Barry (2006) stressed the same point indicating that results of the price-based notion are not likely informative without deeper understanding of the structure and institutions relevant to the markets in question. However, factors such as inter market transportation costs, transactions costs, and government trade policies are not considered in this paper due to data constraints.

Threshold price transmission analysis is used extensively in analyzing commodity prices by numerous researcher, for example, Richardson (1978), Ward (1982), Kinnucan, H.W. and Forker (1987), Hahn (1990), von Cramon-Taubadel (1998), Goodwin and Harper 1999), Goodwin and Piggott (2001), and Meyer, and von Cramon-Taubadel (2004). Other researchers used the LOP framework to test hypotheses about market integration such as Richardson (1978), Ravillion (1986), Ardeni (1989), Baffes (1991) Goodwin and Schroeder (1991), Sexton, et al (1991), Bernard and Willett (1996), Abdulai (2000), and Goodwin and Barry (2006). McNew (1996) identified market integration with market connectivity, whereby connectivity relates to the transmission of price shocks in both spatial and temporal terms. Fackler and Goodwin (2000) pointed out that market integration often refers to a measure of degree rather than a specific relationship. At one extreme markets are completely segmented and at the other extreme they are completely integrated.

Vollrath and Hallahan (2006) applied models based on the Low of One Price (LOP) in some form or another to investigate meat market integration between the United States and Canada. They found that the two markets are

[3] Integration is defined as the satisfaction of the Low of one price (LOP) in some form or another. The LOP states that if trade occurs and all profitable arbitrage opportunities are extinguished, prices are equalized up to the cost of commerce.

segregated for whole chicken. Also, the Canadian-US hog- and pork products markets are more integrated than the Canadian-US steer-and beef-product markets.

This paper adopted the market connectivity approach to focus on the dynamics of price shocks transference caused by the HPAI-outbreaks in ECOWAS. We applied three spatial structural models and developed one temporal dynamic model to capture the main objectives. However, any conclusions that ECOWAS markets are integrated or segregated does not, per se, imply an efficient spatial allocation, in a Pareto optimality sense of competitive market equilibrium due to data constraints.

Data Sources

Several time-series data were collected individually for each of the 15-countries of ECOWAS[4], then one single weighted average price was calculated for poultry, beef, pork, sheep & goat representing ECOWAS region from 1999-2014. International prices of poultry, beef, pork, and mutton, were compiled directly from the IMF database. Since ECOWAS has no common currency at present[5], we computed one ECOWAS-wide exchange rate and also developed a new method "Reverse Transition Dummy Variable" to evaluate the impact of Avian Influenza ECOWAS meat imports. Details on methodology used to derive these data are shown in next section.

1- Domestic and International Prices

Domestic meat producers' price–series for beef, pork, poultry, and combined sheep and goat were compiled for each country, deflated using country-specific CPI, and converted to US dollars using country-specific local currency to US dollar (LCU/USD) exchange rates. Then, the data set is converted to one ECOWAS weighted-average price-series by using per capita consumption as the weight or more formally as following:

$$(1) \qquad P_{jkt}^{WA} = \left[\frac{Q_{jkt}/POP_{jt}}{\sum_{j=1}^{N}(Q_{jkt}/POP_{jt})}\right] P_{jkt}$$

where j represents countries listed above, k represents commodities beef, pork, poultry, or sheep & goat, and t represents time so that P^{WA} is the weighted average price of meat k for country j in time t, P_{jkt} is price of commodity k for country j in time t, Q_{jkt} is quantity supplied[6] of commodity k for country j during time t, and POP_{jt} is the population of country j at time t.

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[4] The 15-ECOWAS countries are: Benin, Burkina Faso, Cape Verde, Cote D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.
[5] ECOWAS has a plan for a common currency, the ECO, was postponed several times, but currently is expected in 2020.
[6] Domestic supply is total production minus exports plus imports plus stock variation for each of the four meats in each of the 15 ECOWAS countries.

From equation (1), the item in brackets is a weight constructed from Qj_{kt}/POP_{jt} defined as total consumption of country j_{ts} meat k at time t divided by population of country j at time t, essentially converting quantity supplied in per capita terms. Using the bracketed term as a weight to P_{jkt} generates a weighted average price-series (P_{jkt}^{WA}) for meat k in country j during time t. Then, the computed weighted average prices are aggregated across country j's form or,

(2) $P_{kt} = \sum_{j=1}^{N} P_{jkt}^{WA}$

Where, P_{kt} is ECOWAS-wide domestic prices for meat $_k$ at time $_t$ in USD. Finally, the constructed series from (2) is converted from yearly to monthly frequency using Bartels, et al. (1998) cubic splining interpolation method and ultimately generating data from January 1999 to December 2014 (192 observations). Time-series data on International prices of poultry, beef, pork, and mutton, were compiled directly from the IMF database from January 1999 to December 2014 in terms of USD[7].

2- Exchange-Rate conversion from local currencies to US dollar

ECOWAS meat prices were converted in terms of USD by using ERS-USDA real exchange rates with base year 2005 from 1999 to 2014 (USDA-ERS-International Macroeconomic data set, October 2015),

(3) $P_{jkt} = E_{\$/LCU} P_{jkt}^{LCU}$

where in (3), P_{jkt} is the price of commodity k for country j in time period t in local currency units (LCU), E$/LCU is the real US dollar to local currency unit exchange rate, and P_{jkt} is price of meat k for country j in time period t deemed in US dollars that was used on the RHS of equation (3).

3- Computing One ECOWAS-Wide Exchange Rate

At present, the ECOWAS region is not under a common Monetary Union though a plan for a common currency, the ECO, is set to be introduced in 2015. The ECO was first planned to be effective in 2003, but was postponed several times to 2005, 2010, 2014, and finally agreed to start in 2015 by the meeting of the Convergence Council of Ministers of West Africa of May 2009 (The Economist, 2014). According to the plan, the ECO will start with six countries: Nigeria, Ghana, Gambia, Guinea, Liberia, and Sierra Leone. Five years later, members of the West African Economic and Monetary Union (known as UEMOA, its French acronym) will adopt the ECO (United States Trade Representative (2014). At present, UEMOA share the West African Franc

[7] International meat prices are marked in the model as $P^{*}kt$, and domestic prices as Pkt for meat k and time t.

(CFA) and is used in eight countries: Benin, Burkina Faso, Cote D'lvoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo. The ECO lunch date of 1 January 2015 was again delayed to 2020 to enable all members to fulfill required financial responsibilities (Africa Review of Business and Technology, 2016).

Estimating the effect of exchange rate on price transmission analysis and assessing what percentage of exchange-rate changes pass-through to commodity prices required the incorporation of one exchange rate for all ECOWAS countries. Therefore, we geometrically mean ECOWAS LCU/USD exchange rates to create an "ECOWAS- wide" exchange rate using following formula (Loretan, Michael, 2005):

$$(4) \qquad E_{ECOWAS/USD,t} = E_{ECOWAS/USD,t-1} \prod_{i=1}^{N(t)} \left(e_{i,t}/e_{i,t-1}\right)^{\omega_{i,t}}$$

where $E_{ECOWAS/USD,t}$ is the value of the "ECOWAS-wide" exchange-rate at time t, $e_{i,t}$ and $e_{i,t-1}$ are the prices of an ECOWAS country's local currency unit i in terms of U.S. dollars at times t, and $t-1$, $w_{i,t}$ is the weight of local currency unit i at time t, $N(t)$ is the number of ECOWAS country local currency units in the exchange rate at time t, and wi. The weight, which is designed to reflect the importance of country $j's$ trade with the US, is constructed by[8],

$$(5) \qquad \omega_{i,t} = \frac{1}{2}\left(\varepsilon_{US,j,t}\right) + \frac{1}{2}\left(\mu_{US,j,t}\right)$$

So that $\varepsilon_{US,j,t} = X_{US,j,t}/\sum_{j=1}^{N} X_{US,j,t}$ representing country $j's$ share of total US exports where $X_{US,j,t}$ is merchandise exports from the US to country j in year t. Analogously, $\mu_{US,j,t} = M_{US,j,t}/\sum_{j=1}^{N} M_{US,j,t}$ represents country $j's$ share of total US merchandise imports where $M_{US,j,t}$ is the merchandise imports from country j to US in year t. Both forms of trade are given equal importance of 1/2, ultimately forming (3). Finally, the intuition behind (4) is that if, for example, the US dollar experiences depreciation, then on average all currencies within the ECOWAS region will experience appreciation, ceteris paribus. Also, equation (4) controls for persistence via a lagged parceled-exchange rate term $E_{ECOWAS/USD,t-1}$.

4- Reverse Transition Dummy Variable

The impact of Avian Influenza was conducted by using a "reverse" transition dummy variable with transitional periods (Reid, 1977) scaled by the amount of periods within the transition phase (Beach, 1977). However, we reversed the order of the scaled transitional phase as we assumed that actual HPAI shocks on economic system

[8] Data for weight construction were based on U S Census Bureau.

were hardest in an initial period and fades slowly over time. Traditionally, transition dummy variable analysis (Wilton, 1975) begins with a linear regression,

$$(6) \qquad Y_t = \alpha_t + \beta_{1t}X_{1t} + \beta_{2t}X_{2t} + \cdots + \beta_{kt}X_{kt} + u_t$$

where it is assumed that intercept α_t and coefficient β_{1t} are constant at some values of α_1 and β_1, respectively over a time period of m observations, then gradually transition over an interval of r periods, and stablizes to another constant value of α_{1T} and β_{1T} respectively over a terminal set of $T - (m + r)$ (Beach, 1977). More details on the model's derivation and the reversion of the transition dummy variables are found in Appendix I.

Empirical Methodology

Methodology

The price transmission analysis is based on the law of one price (LOP) where three models were developed following (Vollrath and Hallahan, 2006), but were essentially modified to capture the major objectives of the paper. In addition, impulse response functions were produced, but only that of poultry is displayed for space limitation.

First, we conducted a dynamic analysis to test for Stationarity in international and ECOWAS meat price time-series applying both Augmented-Dickey Fuller (ADF) and Phillips-Perron (PP) tests. The data are then fitted under a VAR model (Sims, 1980) and were used for generating Impulse Response Functions (IRFs) to examine market linkages between ECOWAS and international meat markets. Granger-causality tests (Granger, 1969), were also conducted to show whether changes in international prices Granger-cause changes in ECOWAS local prices and alternatively whether ECOWAS local prices Granger-cause international price changes. By introducing both spatial and temporal market integration, the analysis was able to gain a better understanding of "market connectedness" via price- transmission (McNew, 1996). The three principle models are developed as follows:

Model 1: Stream-lined Model

Based on the Law of One Price (LOP), the model is used to analyze price transmission and as a foundation to subsequent analysis,

$$(7) \qquad p_{kt} = \beta_0 + \beta_1 p^*_{kt} + \varepsilon_t$$

where, $p_{kt} = \ln(P_{kt})$ and $p^*_{kt} = \ln(P^*_{kt})$ are log of ECOWAS-wide and international commodity k prices at time t, respectively, β_0 is intercept term, β_1 is price transmission elasticity, where if p^*_{kt} changes by 1 percent then β_1 *percent* of that change is transmitted to ECOWAS domestic prices p_{kt}, and the error term ε_t is $\varepsilon_t \sim \text{i.i.d } N(0, \sigma^2)$ and σ^2 is constant variance. Equation (7) is deemed the "Simple LOP Regression" model used as function to subsequent analysis.

Model 2: Intermediate Detailed model

This model is used to estimate the impact of exchange rates on price transmission analysis, whereby the exchange rate is implemented.

$$(8) \qquad p_{kt} = \beta_0 + \beta_1 p^*_{kt} + \beta_2 e_t + \varepsilon_t \quad ,$$

where, all variables and error term are analogous to (7) with the exception of incorporating the log of the ECOWAS-wide exchange rate; $e_t = ln(E_{ECOWAS/USD,t})$. For intuition, if the ECOWAS-wide exchange rate changes by 1-percent, then β_2 *percent* of that change will be transmitted to domestic prices p_{kt}.

Model 3: Augmented-detailed Model

The model was used to capture the impact of HPAI outbreaks on meat price transmission to ECOWAS and international markets among other endogenous and exogenous variables. We incorporated a dummy variable with transitional periods (Reid, 1977) scaled by the amount of periods within the transition phase (Beach, 1977). However, we reversed the order of the scaled transitional phase as we assumed that actual HPAI shocks on economic system were hardest in an initial period and fades slowly over time. The model is an augmented version of (8), as shown in the following,

$$(9) \quad p_{kt} = \beta_0 + \beta_1 p^*_{kt} + \beta_2 e_t + \beta_3 A_t + \beta_4 A_t p^*_{kt} + \beta_5 A_t e_t + \beta_6 S_t + \varepsilon_t$$

Where, A_t represents a transitional dummy variable for HPAI (H5N1) discussed in more details in Appendix I. Initially, HPAI (H5N1) outbreaks started in Africa September, 2005 and the shock faded to 0 on March, 2009. Thus A_t accounts for this transition period where the percentage of β_3 – value is transmitted to domestic price p_{kt}. Both $A_t p^*_{kt}$ and $A_t e_t$ are interaction terms that account for the impact of Avian Influenza with international prices and exchange rates, respectively on domestic prices. During the Avian Influenza transition phase, a 1-percent change in p^*_{kt} is transmitted in the amount of β_4 percent to p_{kt}. *Also*, a 1-percent change in e_t is transmitted in the amount of β_5 percent to p_{kt}. Furthermore, S_t is a seasonality dummy variable to account for price changes in

November, December, and January (to capture effects of Thanksgiving, Christmas, and New Year, respectively) where S_{tt}= 1 if these months occur and S_{tt}= 0 otherwise, so that if the former is true then p_{kt} changes by β_6 $percent$. Finally, all other variables are analogous to descriptions for equations (7) and (8).

Temporal Dynamic Structural Model

This model conducted a range of dynamic analysis models utilizing VAR analysis coupled with impulse response functions (IRFs), to view the magnitude of shocks on domestic and international meat prices. However, we first examined data for Stationarity & Cointegration by conducting unit root tests, augmented by Dickey-Fuller (ADF) tests, and Phillips-Perron (PP) tests. Both domestic prices (p) and international prices (p*) were assumed to undergo an AR (1) process when tests were performed over each *k* meat. Results indicated that both domestic and international series were stationary according to (ADF) tests at 1 percent and 5 percent significance level. For cointegration, Granger-cointegration tests were conducted where all meat price series rejected the null hypothesis of cointegration at 1 percent levels.

VAR Analysis and impulse response functions

Next, and aside from spatial analysis, it was important to account for dynamic effects in the instance of exogenous shocks. Using VAR analysis and impulse response functions, we were able to further examine the degree of market segmentation and market integration. More details on the VAR model are found in Appendix II.

Empirical Results

Results of all models are discussed in the following.

1- Price Transmission from ECOWAS to International markets and vice versa

Table 1 show results of the simple LOP regression equation (7) using ordinary least squares regression. The 4-rows with "ECOWAS" preceding each meat regress international prices p^*_{kt} onto ECOWAS prices (p_{kt}) indicating changes in international meat prices (Int) due to changes in ECOWAS meat prices. The lower part of table 1 shows 4 rows with (Int) preceding result of each meat regress p_{kt} onto p^*_{kt} , showing the impact of domestic prices on the international prices, using the same form of equation (7) but changing p^*_{kt} for p_{kt}.

ECOWAS row of Table (1) shows that each meat price's intercept term is highly significant at the 1 percent level, except price intercept of Sheep & Goat. Likewise, all price transmission elasticities are statistically significant for all 4-meats at the 1 percent significant level. Elasticities indicated that if international prices change for meat k, by 1 percent, then ECOWAS prices change by 0.41percent, 0.19 percent, 2.04 percent, and 0.92 percent for beef, pork, poultry, and Sheep & Goat, respectively. These results indicated that ECOWAS poultry is very sensitive (elastic) to changes in international poultry changes, while pork and beef are inelastic or insensitive to changes in international prices.

The ECOWAS poultry elasticity coefficient of 2.04 percent suggests ECOWAS poultry market is well integrated with international poultry markets. Indeed, poultry showed the largest growth in per capita consumption and the fastest import share of all meats. In contrast, insensitivity of pork within ECOWAS countries was mainly due to its overall small quantities produced, consumed, and imported

Beef, insensitivity or inelasticity is mainly due inaccurate reporting of the number of cattle slaughter and meat sale. Per capita beef consumption fluctuated within a very narrowly range from 3.2 kg/year in 1999 to 3.3 kg/year in 2014, reflecting most likely inaccurate sales reporting to government officials by the frequently moving cattle-tribes, notably the Fulani tribe. With an almost-unitary elasticity coefficient of 0.92, ECOWAS sheep & goat market lean more towards integration with international markets through transmitting about perfect price signals from international markets.

The lower part of Table 1 shows the elasticity coefficient of international beef and pork markets being integrated with analogous ECOWAS meat markets, as changes in ECOWAS prices are elastic (2.09 percent for beef prices and 1.38 percent for pork). These high elasticities indicate that price signals from the ECOWAS region relay clearer to international markets than the opposite direction shown in the upper part of Table 1. For international poultry prices, the signals from ECOWAS are weak as the coefficient is inelastic at 0.264 percent suggesting international markets lean toward segmentation with ECOWAS. This pattern is consistent with the small quantities of ECOWAS poultry imports.

2- The Impact of ECOWAS-wide Exchange rate

Adding the ECOWAS/USD exchange rate variable into equation (7) to construct a new equation (8) caused the explanatory power or the coefficient of determination R^2 of equation (8) to be higher reflecting the changes due to impacts of ECOWAS exchange rates. These impacts can be seen by the higher value of the adjusted coefficient of determinations (R-squared values), located in the last row of Table 2 compared to those reported in Table 1.

The incorporation of ECOWAS-wide exchange rate in equation 8 showed inelastic effect on transmitting beef, pork, sheep &goat prices in ECOWAS, but inelastic effect on poultry price transmission from international market to ECOWAS. Alternatively, price transmission due to changes in ECOWAS-wide exchange rate was elastic for beef, but inelastic for all remaining meats.

Basically, if the USD depreciates, it results in higher $E_{ECOWAS/USD,t}$ exchange rate value, resulting in or transmitted as a decrease in meat prices in ECOWAS and other international markets. In the "ECOWAS" row of Table 2, meat prices for beef, pork, and sheep & goat are inelastic to changes in ECOWAS-wide exchange rate, but elastic for poultry. Alternatively, in the (Int) row (Table 2), meat prices for beef are elastic to changes in ECOWAS-wide exchange rate while the remaining meats are inelastic.

Furthermore, incorporation of ECOWAS-wide exchange rate in equation (8) showed inelastic effect on transmitting beef, pork, sheep & goat prices in ECOWAS, but elastic effect on poultry price transmission from international markets to ECOWAS. Alternatively, price transmission due to changes in ECOWAS-wide exchange rate was elastic for beef, but inelastic for all remaining meats.

3- The Impact of HPAI on price Transmission

Impacts of the HPAI-outbreaks are conducted utilizing equation (9) and running Wald tests individually for each meat to evaluate market integration and segmentation, according to the following criteria.

For the pre-HPAI period, perfect (zero) transmission of international market prices to domestic market prices occurs if $\beta_2 = 1(0)$, complete (zero) exchange-rate-pass-through implies that $\beta_2 = 1(0)$, and perfect market integration (complete market segmentation) occurs if $\beta_1 = \beta_2 = 1(0)$. Alternatively, for the post-HPAI period, perfect (zero) price transmission of international market prices to domestic market prices occurs if $(\beta_1 + \beta_4) = 1(0)$, complete (zero) exchange-rate-pass-through occurs when $(\beta_2 + \beta_5) = 1(0)$, and perfect market integration (complete market segmentation) takes place when $(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 1(0)$.

Results of the HPAI impact on ECOWAS market across commodity k =beef, pork, poultry, and sheep & goat are shown in Table 3A. In analogous, impact of HPAI on international markets are displayed in table (3B) with P_{kt} and P^*_{kt} interchanged (i.e. using international prices P^*_{kt} instead of domestic prices P_{kt}).

In ECOWAS markets, HPAI impact was negative and large on poultry price (-8.82 percent), and positive increasing beef and pork prices by 0.70 percent and 1.37 percent, respectively. However, in the international markets, HPAI impact on poultry was negative and smaller (-3.85 percent), but positive with a larger impact on beef and pork, boosting prices higher by 2.60 percent and 33.61 percent, respectively. These results indicated that HPAI- outbreaks in ECOWAS has much larger consequences on ECOWAS poultry markets than on international markets. They also shows the important role of beef, pork, sheep & goat meats as potential substitutes for poultry in the European Union (EU-27) (Taha & Hahn, 2015) and in Japan (Ishida, et.al, 2010). In ECOWAS, however, the substitution effect was not as strong, mainly due small per capita consumption and higher prices of beef, pork, and sheep. Lastly, HPAI impact on sheep & goat price was mixed; negative in ECOWAS but positive in International markets, most likely due to the larger role of sheep & goat meat as substitutes in the international rather than ECOWAS markets.

Table (3A) indicated that seasonality has positive impacts on ECOWAS beef, poultry, and sheep & goat, but negative impact on pork prices, all of which were a fraction of 1-percent and statistically insignificant. At international markets (Table 3B), seasonality impact was only a fraction of 1-percent, positive and significant at the 5 percent level only for beef but negative for all other meats.

Testing for market integration (segmentation) suggested that ECOWAS and international meat markets are neither perfectly integrated nor perfectly segregated, during both the pre- and post HPAI era. These results are based on testing two hypothesis (shown in Table 3A and 3B):

1- The hypothesis of perfect market integration $(\beta_1 = \beta_2 = 1; (\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 1)$. This hypothesis is rejected for all ECOWAS and international meats both pre and post HPAI at the 1 percent level.
2- The hypothesis of perfect market segmentation $(\beta_1 = \beta_2 = 0; (\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 0)$. This is globally rejected for all ECOWAS and international markets during both the pre- and post-HPAI at the 1 percent significant level, except for poultry, which was insignificant.

The idea that poultry was perfectly segmented pre-HPAI but neither perfectly segmented nor perfectly integrated post-HPAI suggests that the region was forced to integrate with international poultry markets to supplement domestic poultry meat shortages in the post-HPAI era, after declaring ECOWAS free-of HPAI in April 2009 and dissipating consumers' fear. The rise in poultry imports averaged 23 percent per year during 2010-2012.

Testing for partial price transmission occurs in all ECOWAS-International meat markets and International-ECOWAS meat markets. Specifically, the notion of complete international price transmission (if looking at "ECOWAS" columns) and complete ECOWAS price transmission (if looking at "Int" columns) $((\beta_1 + \beta_4) = 1)$ are all rejected at the 1 percent alpha level. Alternatively, the hypothesis of zero price transmission for both ECOWAS- International and International-ECOWAS meat markets $((\beta_1 + \beta_4) = 0)$ are universally rejected at 1 percent alpha level. This implies that ECOWAS meat markets became more integrated with international markets in the post-HPAI era.

4- Post-HPAI Impact on Exchange Rates

The case for post-HPAI complete exchange-rate pass through $((\beta_2 + \beta_5) = 1)$ using Wald statistical tests is weak because the hypothesis for all meat prices for ECOWAS-International markets and International-ECOWAS markets are rejected at 1 percent alpha level. Testing for post-HPAI zero exchange-rate pass through $((\beta_2 + \beta_5) = 0)$ were rejected at 1percent level (Table 3B). Also, ECOWAS- International sheep & goat prices failed to reject zero exchange rate pass through hypothesis (Table 3A). The latter result implies that no exchange rate signals pass through to ECOWAS sheep & goat markets, most likely due to the market's small quantities.

The situation where ECOWAS-International and International-ECOWAS prices transmit in the same manner as the ECOWAS-wide exchange rate for pre-HPAI $(\beta_1 = \beta_2)$ is rejected for all meats at 1 percent level, except for International-ECOWAS beef prices, which is rejected at 5 percent level. Failures to reject this hypothesis occurred in ECOWAS- International beef prices and ECOWAS-International sheep & goat prices suggest that prices and exchange rates move symmetrically to one another, showing small impact.

Regarding the post-HPAI scenario $((\beta_1 + \beta_4) = (\beta_2 + \beta_5))$, or the notion that bilaterally speaking, price transmission occurred in the same manner as the exchange rate is rejected for all meats at 1 percent level, with the exception of international-ECOWAS pork and poultry prices were rejected at the 10 percent level. Note that the scenario $((\beta_1 + \beta_4) = (\beta_2 + \beta_5))$ implies that changes in International-ECOWAS meat prices or ECOWAS-International meat prices due to exchange rate movements $(\beta_1 + \beta_4)$, are equivalent to changes in International-ECOWAS meat prices and ECOWAS-International meat prices due to HPAI, or $(\beta_2 + \beta_5)$. However, since Wald tests rejected this equivalence for all meat prices, we can conclude that changes to meat prices due to exchange rates *are different* than changes to meat prices due to HPAI, regardless of exchange rate's impacts on the market.

5- Results of the VAR Analysis and Impulse Response Functions

Next we discuss results of the VAR analysis and impulse response functions that accounted for the dynamic effects of the instance HPAI exogenous shocks. We were able to further examine ECOWAS degree of market segmentation and/or integration. Step-by-step derivation of the used VAR model, based on Vollrath and

Hallahan (2006) is presented in Appendix II. Though, we added 3 new exogenous variables to meet the main objectives of the paper. First, we added a reverse transitional dummy variable to account for the effect of HPAI effect on meat prices (domestic and international), second seasonality dummy variables, and third an ECOWAS-wide exchange rate variable. Also, we used a more practical equation form better suited for conducting and displaying the impulse response analysis of the four meats (see Appendix II).

5.1 Temporal Analysis and Impulse Response Function Displays

In the subsequent sections, equation (A9, Appendix II) is taking the form of a VAR (1), so that essentially used (m=1) model for simplicity and to facilitate the estimation of the basic impulse response inference patterns between international and ECOWAS meat prices.

Table 4. Granger causality tests

	Chi-square statistics	
	$p^{Int} \rightarrow p^{ECOWAS}$	$p^{ECOWAS} \rightarrow p^{Int}$
Beef	6.47**	0.29
Pork	3.96**	1.52
Poultry	0.85	4.36**
Sheep & Goat	15.50***	16.04***

* Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.05 level, and ***at the 0.01 level

Table 4 presents Granger-causality tests, showing the connectivity (or lack-thereof) between ECOWAS and international markets, using block-exogeneity-Wald tests. Results show that international beef, pork, and sheep & goat market prices granger-cause ECOWAS market prices of like meats at 1 percent level for sheep & goat and 5 percent level for beef and pork. However, connectivity in the international poultry market to ECOWAS poultry market is weak (insignificant).

The second column of table 4, suggests that ECOWAS beef and pork prices do not granger-cause international beef and pork prices, so the connectivity is weak. However ECOWAS poultry and sheep & goat prices have strong connection; they followed international prices. During the Post-HPAI, poultry was imported to meet shortages of domestic requirements, while sheep & goat have a special role within ECOWAS Moslem Communities, whereby families are to sacrifice an animal at Festival of Sacrifice Celebration, thus prices are not a first consideration.

5.2- Inference from Impulse Response Functions

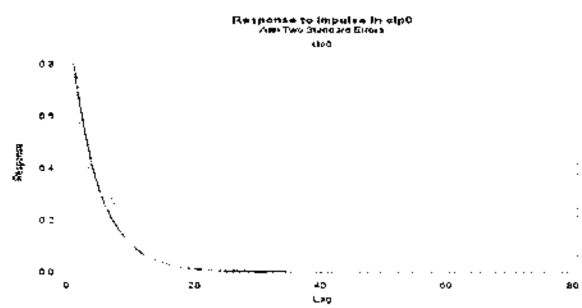
Impulse response functions per period (month) in both ECOWAS and international markets were compared for poultry, beef, pork, and sheep & goat meats. However, only impulse response functions of poultry are displayed below, due to space limitation.

Poultry- displays

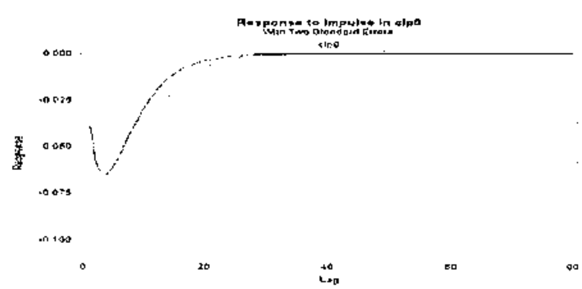
Impulse response functions of poultry prices

Response in local poultry market on an Int'l price shock

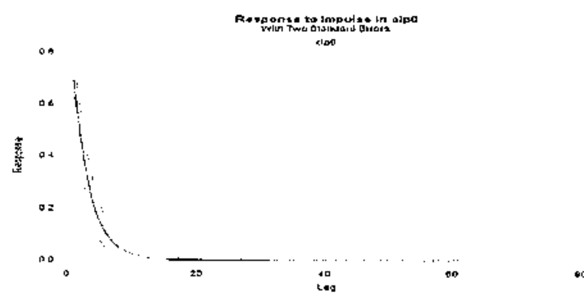
Response in local poultry market on local price shock



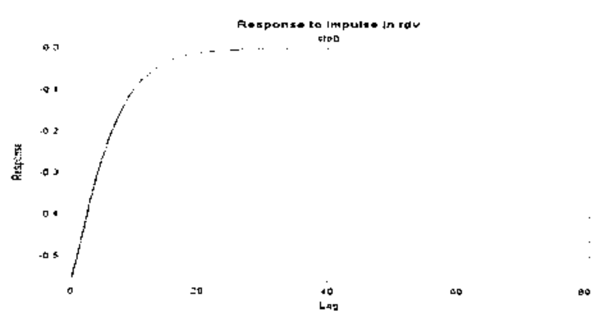
Response in International poultry market on local price shock



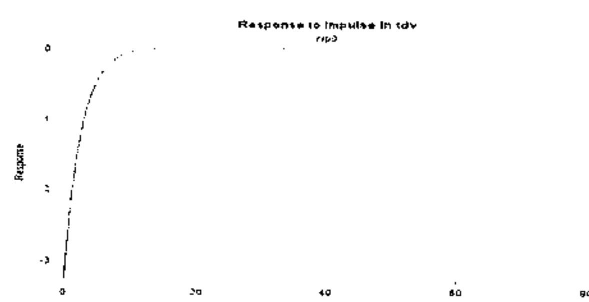
Response in international poultry market on international price shock



Response in local poultry market to HPAI shock



Response in international poultry market to HPAI shock



The top row of the display shows responsiveness of ECOWAS poultry prices to one-standard-deviation (plus/minus two standard errors) shocks in international and own-price shocks respectively. The middle row shows responsiveness of international poultry prices to one-standard-deviation (plus/minus two standard errors) shocks in ECOWAS and own-price respectively. The final row shows responsiveness of ECOWAS and international poultry prices to HPAI shocks, respectively.

The top row of the display indicated that ECOWAS poultry prices are not responsive to international price shocks and decay rather quickly, suggesting lack of connectivity of international to ECOWAS poultry markets which is confirmed by the Granger-causality test computed above (see Table 4). As for own-price ECOWAS poultry price shocks, caused local poultry prices to increase by about 0.8 percent that took over 20 periods to decay.

In reference to the middle row, responsiveness of international poultry prices to ECOWAS poultry price shocks is rather small, where a one-standard deviation shock in ECOWAS prices transmits as a .06 percent decrease in international prices, and the effect remains longer about 30-40 periods. This suggested weak connectivity of ECOWAS to international poultry markets, also confirmed by Granger-causality test for this case where the null of no causality was rejected at the 5 percent statistical level. Responsiveness of international poultry markets to a one-standard deviation own-price shock translates as an 0.7 percent increase in prices whose effect decays in about 10 periods suggesting the international market recovers relatively rapidly from such shocks.

The bottom row shows the effect of an HPAI shock to international poultry prices was relatively small in magnitude, causing an instantaneous decrease of 3.2 percent in international prices compared to a decrease of nearly 6.0 percent[9] in ECOWAS). The larger impacts of HPAI in ECOWAS price and the longer recovery period before decaying from the shock reflect a stronger fear of HPAI in ECOWAS countries relative to the international communities. This is most likely due to the superior measures undertaken in poultry exporting countries against the HPAI infection in poultry flocks including surveillance and biosecurity measures, medical care and prevention methods.

Concluding remarks

Results of spatial models, alongside multiple Wald-tests for market integration/segmentation suggested that neither ECOWAS nor international meat markets were fully integrated or segmented both pre- and post HPAI, except for poultry. Wald tests found poultry to be perfectly segregated in the pre-HPAI, but became more integrate in the post-HPAI, as evidenced by the rise in imports at an average annual rate of 23 percent during 2010-2012.

[9] Regression analysis of the detailed-augmented LOP model indicated a decrease of 3.85 for the international markets and 8.82 for ECOWAS (Table 3). The HPAI impact on international prices may be largely attributed to HPAI-outbreaks in EU-28 (large market) reported by Taha & Hahn (2015), and only partially if at all by the outbreaks in ECOWAS (being a small market).

The incorporation of HPAI into price transmission analysis caused ECOWAS poultry prices to decrease by 8.82%, compared to a decrease of 3.5 percent on world markets, reflecting a stronger consumers' fear in ECOWAS than in international communities. Price decreases in international markets were most likely caused by a simultaneously 2006 HPAI-outbreaks in EU-27 (large market) compared to ECOWAS (small market). The HPAI shocks also increased the international prices of beef (2.6 percent), pork (33.61 percent), and sheep & goat prices (14.99 percent), much higher than in ECOWAS, during the time from September 2005 to February 2009. Higher international prices were triggered by rising demand, suggesting that the international community viewed beef, pork, and sheep & goat as substitutes for poultry. Per capita consumption of beef, pork and sheep are much larger in the international markets than in ECOWAS.

Inference from Impulse Response Functions indicated that recovery from price shocks of poultry in ECOWAS took about 20 periods before decaying to equilibrium, compared to 10 periods in international markets. This is mainly due to superior prevention methods undertaken against the HPAI infection in poultry flocks, including surveillance and biosecurity measures, medical care, and others. Recovery from price shocks of beef, pork, and sheep & goat took 40 to 80 periods before decaying to steady-state equilibrium, due to the relatively longer live-cycles for cattle, pork, and sheep & goats.

Additionally, a temporal analysis was conducted where a VAR (1) model was exploited and used to generate IRF s. Granger causality tests were conducted which added support to findings from the IRF's in that to some degree beef, pork, and poultry markets were integrated since ECOWAS prices were found to Granger-cause international prices for poultry and international prices were found to Granger-cause ECOWAS prices for beef and pork. However sheep & goat markets are bilaterally integrated since Granger-causality was found for international-ECOWAS prices and ECOWAS-international prices for sheep & goat, where this integration was reflected in the IRF's where price shocks translated into both responsiveness and long decay rates.

Finally, exchange rate analysis indicated that ECOWAS prices of beef, pork, and sheep & goat are relatively more inelastic to changes in ECOWAS-wide exchange rates compared to poultry. Alternatively, the international prices for beef are elastic to changes in ECOWAS-wide exchange rate while all other meats are inelastic. Changes in meat price due to HPAI outbreaks do matter when trading poultry and pork meat in the post-HPAI years, regardless of exchange rates' impact. Seasonality was only a fraction of less than one-tenth percentage point, positive or negative and mostly insignificant in both ECOWAS and international markets.

Appendix I
Derivation of HPAI-Reverse Transition Dummy Variable

To investigate the impact of the HPAI (H5N1) in the analysis, we incorporated a dummy variable with transitional periods (Reid, 1977) scaled by the amount of periods within the transition phase (Beach, 1977). However, we reversed the order of the scaled transitional phase as we assumed that actual HPAI shocks on economic system were hardest in an initial period and fades slowly over time. The analysis of the transition dummy variable (Wilton, 1975) begins with a linear regression,

(A1) $$Y_t = \alpha_t + \beta_{1t}X_{1t} + \beta_{2t}X_{2t} + \cdots + \beta_{kt}X_{kt} + u_t$$

where it is assumed that intercept α_t and coefficient β_{1t} are constant at some values of α_{10} and β_{10} respectively over a time period of m observations, then gradually transition over an interval of r periods, and stabilizes to another constant value of α_{1T} and β_{1T} respectively over a terminal set of $T - (m + r)$ (Beach 1977). To accommodate this transition, assume α_t and β_{1t} evolve according to the degree p polynomial,

(A2) $\alpha_t = \alpha_0 + c_1 l + c_2 l^2 + \cdots + c_p l^p$ and,

(A3) $\beta_{1t} = \beta_{10} + \gamma_1 l + \gamma_2 l^2 + \cdots + \gamma_p l^p$

Where, in (A2) and (A3), $l = 0, 1, 2, \ldots, r, r + 1$ where $l = t - m$. Following our specification for l, the transitional dummy variable can be modeled as,

(A4) $\mathrm{D} = \{0, 0 \ldots, 0;\ 1, 2, \ldots, r\ ;\ r + 1, r + 1, \ldots, r + 1\} = \{\mathrm{d_t}\}$

Where D is constant at 0 from the initial period until period m, at which point the structural change occurs and linearly increases for r periods and remains constant at r thereafter. However, we can scale (A4) by $1/r$ (Reid 1977) to yield,

(A5) $\mathrm{D} = \left\{0, 0 \ldots, 0;\ \frac{1}{r}, \frac{2}{r}, \ldots, \frac{r-1}{r}\ ;\ 1, 1, \ldots, 1\right\} = \{\mathrm{d_t}\}$

Now, using (A5) we "reverse" D to yield,

(A6) $\mathrm{Z} = \left\{1, \ldots, 1, 1;\ \frac{r-1}{r}, \ldots, \frac{2}{r}, \frac{1}{r};\ 0, \ldots, 0, 0\right\} = \{\mathrm{z_t}\}$

Where, Z is the reverse transition dummy variable vector, avian Influenza is believed to make the largest impact at the beginning of a shock period and then slowly weaken during the transition period, as indicated in equation (A6).

Using (A6) and inserting into (A2) and (A3) for l and ultimately placing the embedded equations into (6) we have,

(A7) $Y_t = [\alpha_0 + c_1 z_t + c_2 z_t^2 + \cdots + c_p z_t^p] + [\beta_{10} + \gamma_1 z_t + \gamma_2 z_t^2 + \cdots + \gamma_p z_t^p] X_{1t} + \beta_{2t} X_{2t} + \cdots + \beta_{Kt} X_{Kt} + u_t$

Where, for simplicity, we assume that (7) and (8) evolve according to a p - 1 order polynomial then equation (A7) becomes equation (A8) as follow,

(A8) $Y_t = \alpha_0 + c_1 z_t + \beta_{10} X_{1t} + \gamma_1 z_t X_{1t} + \beta_{2t} X_{2t} + \cdots + \beta_{Kt} X_{Kt} + u_t.$

Appendix II

Vector Auto regression (VAR) Analysis

Aside from spatial analysis, we accounted for the dynamic effects in the instance of exogenous shocks, using VAR analysis and impulse response functions. This way, we are able to further examine the degree of market segmentation (impulses are less responsive and longer decay-horizons) and market integration (impulses are more responsive and shorter decay horizons).

Development of the VAR model is as follows, (A9) $P_{hkt} = \sum_{l=1}^{m} \beta_{hkl1} P_{1kt-1} + \sum_{l=1}^{m} \beta_{hkl2} P_{2kt-1} + \sum_{l=1}^{12} \beta_{hkl3} S_l + \beta_{hkl4} e_t + \beta_{hkl5} A_t + \beta_{hkl6} A_t P_{1kt} + \beta_{hkl7} A_t P_{2kt} + \beta_{hkl8} A_t e_t + \varepsilon_{ht}$

Basically, we followed (Vollrath and Hallahan 2006) but added an additional dimension k. Now, each coefficient is indexed in four dimensions where h is either equation 1 or 2 (h=1, refers to international prices and if h=2 then the equation refers to ECOWAS prices), k is commodity, l is either lag-length or season from period 1 to m, and the fourth indexes position of each variable in the equation. P_{hkt} is equation h commodity k price at time t where if $h = 1$ then $P_{1kt} = pkt$ and if $h = 2$ then $P_{2kt} = p_t^*$, P_{1kt-l} is l-period lagged ECOWAS-wide commodity k prices, and P_{2kt-l} is l-period lagged international commodity k prices.

For the exogenous variables, S_l is seasonal dummy variable indexed by season l, A_t is transitional dummy variable describing HPAI at time t, finally $A_t P_{1kt}$, $A_t P_{2kt}$, and $A_t e_t$ are interaction terms describing the contemporaenous time t effect of HPAI with ECOWAS-wide meat prices, international meat prices, and ECOWAS-wide exchange rate respectively. For simplicity we used the following equation to estimate the model.

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Figure 1 · ECOWAS import share of poultry meat during 2004-2009 HPAI-outbreak

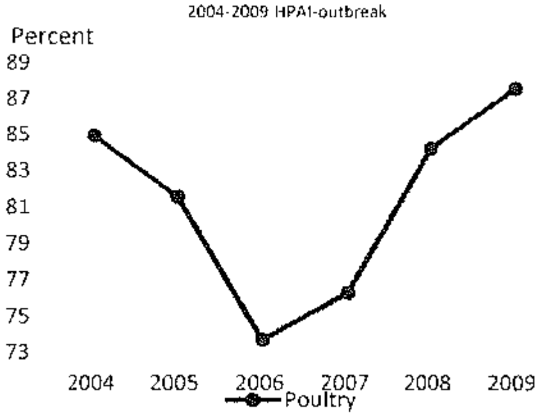

Figure 2: ECOWAS import shares of beef, pork and sheep meat during 2004-2009 HPAI-outbreak

Source: World Trade Atlas, March 2016

Table 1. The Streamlined law-of-one price model

Exporting country own-currency	H_0	ECO Beef	ECO Pork	ECO Poultry	ECO Sheep & Goat
Intercept	$\beta_0 = 0$	3.878*** (0.098)	6.513*** (0.173)	-7.664*** (1.047)	0.270 (0.206)
Partner USD domestic price	$\beta_1 = 0$	0.411*** (0.012)	0.191*** (0.024)	2.043*** (0.141)	0.915*** (0.026)
Goodness of fit	Adj. R^2	0.84	0.22	0.56	0.85
		I. Beef	I. Pork	I. Poultry	I. Sheep & Goat
Intercept	$\beta_0 = 0$	-6.989*** (0.450)	-3.652*** (1.363)	5.441*** (0.137)	0.664*** (0.206)
Partner USD domestic price	$\beta_1 = 0$	2.088*** (0.063)	1.381*** (0.173)	0.264*** (0.018)	0.967*** (35.83)
Goodness of fit	Adj. R^2	0.86	0.26	0.54	0.88

* Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.05 level, and ***at the 0.01 level

Table 2. The detailed law-of-one price model

Exporting country own-currer	H_0	ECO Beef	ECO Pork	ECO Poultry	ECO Sheep & Goat
Intercept	$\beta_0 = 0$	7.043*** (0.311)	8.370*** (0.145)	13.411*** (3.009)	4.276*** (0.499)
Partner USD domestic price	$\beta_1 = 0$	0.044 (0.036)	-0.049** (0.019)	-0.698* (0.393)	0.457*** (0.058)
Exchange rate	$\beta_2 = 0$	-0.589*** (0.056)	-0.242*** (0.013)	-1.479*** (0.201)	-0.602*** (0.070)
Goodness of fit	Adj. R^2	0.91	0.74	0.64	0.92
		Int. Beef	Int. Pork	Int. Poultry	Int. Sheep & Goat
Intercept	$\beta_0 = 0$	7.188*** (1.139)	13.171*** (2.250)	7.864*** (0.114)	3.713*** (0.623)
Partner USD domestic price	$\beta_1 = 0$	0.186 (0.153)	-0.710** (0.281)	-0.025* (0.014)	0.599*** (0.076)
Exchange rate	$\beta_2 = 0$	-1.367*** (0.105)	-0.624*** (0.072)	-0.514*** (0.020)	-0.462*** (0.090)
Goodness of fit	Adj. R^2	0.93	0.48	0.901	0.90

* Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.05 level, and ***at the 0.01 level

Table 3A. The detailed-augmented law-of-one price model ECOWAS Markets

Exporting country own-currency domestic price	H_0	Beef	Pork	Poultry	Sheep & Goat
Intercept	$\beta_0 = 0$	8.810***	7.487***	3.854	6.373***
		(0.567)	(0.277)	(3.421)	(0.553)
Partner USD domestic price	$\beta_1 = 0$	-0.175**	0.066*	0.510	0.193***
		(0.067)	(0.036)	(0.445)	(0.064)
Exchange rate	$\beta_2 = 0$	-0.104*	-0.084	-0.003	0.302**
		(0.060)	(0.066)	(0.319)	(0.119)
AI	$\beta_3 = 0$	0.702	1.371***	-8.818*	-4.513***
		(0.606)	(0.328)	(4.879)	(0.856)
AI times partner price	$\beta_4 = 0$	-0.094	-0.169***	1.345**	0.509***
		(0.071)	(0.043)	(0.6360)	(0.098)
AI times exchange rate	$\beta_5 = 0$	-0.725***	-0.274***	-1.696***	-0.293**
		(0.076)	(0.065)	(0.378)	(0.143)
Seasonality	$\beta_6 = 0$	0.007	-0.006	0.009	0.004
		(0.007)	(0.007)	(0.029)	(0.013)
Goodness of fit	Adj. R^2	0.96	0.79	0.89	0.96
Post-AI					
Price transmission elasticities	$\beta_1 + \beta_4 = 0$	[73.18]***	[18.35]***	[24.11]***	[120.43]***
	$\beta_1 + \beta_4 = 1$	1634.1]***	[2075.7]***	[5.12]***	[21.70]***
Post-AI					
ERPT elasticities	$\beta_2 + \beta_5 = 0$	332.63]***	[220.45]***	[85.84]***	[0.01]
	$\beta_2 + \beta_5 = 1$	1620.2]***	[3161.4]***	[216.66]***	[121.90]***
Pre-AI					
Foreign price = exchange - rate	$\beta_1 = \beta_2$	[1.54]	[10.82]***	[15.88]***	[1.08]
Post - AI					
Foreign price = exchange - rate	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5)$	511.93]***	[113.53]***	[226.21]***	[245.39]***
Pre-AI					
H0: complete market segmentation	$\beta_1 = \beta_2 = 0$	[6.80]***	[19.17]***	[3.85]	[10.61]***
H0: perfect market integration	$\beta_1 = \beta_2 = 1$	403.40]***	[684.61]***	[15.88]***	[158.93]***
Post-AI					
H0: complete market segmentation	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 0$	515.34]***	[235.17]***	[777.78]***	[558.63]***
H0: perfect market integration	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 1$	1755.1]***	[3545.3]***	[1150.6]***	[246.34]***

Note: Parentheses denote t statistics; brackets denote Wald statistics.

* Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.05 level, and ***at the 0.01 level

Table 3 B. The detailed-augmented law-of-one price model International Markets					
Exporting country own-currency domestic price	H_0	I. Beef	I. Pork	I. Poultry	I. Sheep & Goat
Intercept	$\beta_0 = 0$	15.039***	-13.926***	9.622***	-10.504***
		(1.724)	(4.838)	(0.409)	(1.214)
Partner USD domestic price	$\beta_1 = 0$	-0.903***	2.713***	-0.247***	2.378***
		(0.235)	(0.606)	(0.053)	(0.150)
Exchange rate	$\beta_2 = 0$	-0.378***	-1.484***	-0.569***	-0.970***
		(0.1052)	(0.153)	(0.047)	(0.118)
AI	$\beta_3 = 0$	2.601	33.610***	-3.851***	14.996***
		(2.009)	(5.587)	(0.526)	(1.350)
AI times partner price	$\beta_4 = 0$	-0.3803	-4.197***	0.443***	-1.834***
		(0.271)	(0.697)	(0.065)	(0.165)
AI times exchange rate	$\beta_5 = 0$	-1.463***	0.381**	0.692***	0.091
		(0.146)	(0.175)	(0.064)	(0.139)
Seasonality	$\beta_6 = 0$	0.040**	-0.127***	-0.005	-0.005
		(0.016)	(0.022)	(0.007)	(0.015
Goodness of fit	Adj. R^2	0.97	0.672	0.94	0.95
Post-AI Price transmission elasticities	$\beta_1 + \beta_4 = 0$	[66.45]***	[28.78]***	[74.20]***	[59.07]***
	$\beta_1 + \beta_4 = 1$	[210.29]***	[80.57]***	[1250.9]***	[41.79]***
Post-AI ERPT elasticities	$\beta_2 + \beta_5 = 0$	[312.98]***	[88.34]***	[4.05]**	[109.14]***
	$\beta_2 + \beta_5 = 1$	[745.51]***	[321.06]***	[204.75]***	[498.76]***
Pre-AI Foreign price = exchange - rate	$\beta_1 = \beta_2$	[5.11]**	[52.31]***	[18.73]***	[353.17]***
Post - AI Foreign price = exchange - rate	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5)$	[43.10]***	[3.78]*	[3.16]*	[794.65]***
Pre-AI H0: complete market segmentation	$\beta_1 = \beta_2 = 0$	[22.30]***	[152.62]***	[188.10]***	[359.32]***
H0: perfect market integration	$\beta_1 = \beta_2 = 1$	[197.26]***	[326.41]***	[1917.9]***	[411.43]***
Post-AI H0: complete market segmentation	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 0$	[622.89]***	[100.85]***	[365.79]***	[829.18]***
H0: perfect market integration	$(\beta_1 + \beta_4) = (\beta_2 + \beta_5) = 1$	[1087.6]***	[398.77]***	[4062.6]***	[863.60]***

Note: Parentheses denote t statistics; brackets denote Wald statistics.

* Denotes the null hypothesis is rejected at the 0.10 significance level, **at the 0.05 level, and ***at the 0.01 level

Table I : ECOWAS per capita meat consumption per country, 1999, 2005, 2012, and 2014

	1999	2005	2010	2014		1999	2005	2010	2014
	Poultry meat/Kg/year					Beef meat/Kg/year			
Benin	8.5	8.4	18.1	23.1	Mali	7.0	8.6	9.8	10.6
Cabo Verde	2.2	11.6	16.8	19.0	Niger	10.6	13.3	8.8	8.3
Liberia	4.1	5.5	6.1	9.6	Burkina Faso	6.0	8.0	7.6	7.1
Ghana	1.9	4.0	5.7	7.5	Senegal	4.9	4.9	5.4	5.7
Togo	3.8	4.6	6.4	7.4	Guinea	3.7	4.5	5.3	5.0
Gambia	1.6	3.8	4.7	5.8	Guinea-Bissau	3.5	3.7	4.1	4.1
Senegal	2.5	4.0	3.7	4.9	Benin	3.0	2.8	3.2	3.1
Sierra Leone	2.5	1.7	3.9	4.6	Gambia	2.6	2.6	2.4	2.3
Mali	2.8	2.7	2.9	2.8	Nigeria	2.5	2.2	2.0	2.2
Guinea-Bissau	1.2	1.4	1.9	2.2	Sierra Leone	1.5	1.4	1.7	1.9
Côte d'Ivoire	1.5	1.5	1.7	2.2	Cabo Verde	1.1	1.6	2.5	1.7
Burkina Faso	2.1	2.2	2.3	2.1	Côte d'Ivoire	2.0	2.0	1.9	1.6
Guinea	0.6	0.9	1.4	1.7	Togo	1.4	1.4	1.4	1.4
Nigeria	1.4	1.5	1.8	1.7	Ghana	1.4	1.4	1.1	1.1
Niger	1.1	0.9	1.1	1.5	Liberia	0.8	0.6	0.7	0.7
ECOWAS poult	1.9	2.2	2.9	3.4	ECOWAS pork	3.2	3.4	3.2	3.3
	Pig meat/Kg/year					Sheep & goat meat/Kg/ye			
Guinea-Bissau	8.5	8.2	8.7	9.3	Mali	6.2	7.0	8.3	8.0
Cabo Verde	16.7	15.6	17.2	6.9	Noger	6.8	6.9	5.7	4.5
Liberia	1.9	2.0	2.8	3.6	Burkina Faso	3.6	3.4	3.3	2.7
Burkina Faso	1.6	2.4	1.9	1.8	Nigeria	2.5	2.7	2.8	2.7
Nigeria	1.3	1.4	1.4	1.4	Cabo Verde	1.2	1.5	2.1	2.1
Togo	1.2	1.4	1.5	1.4	Senegal	1.6	1.4	1.6	1.8
Côte d'Ivoire	0.4	0.7	0.8	1.0	Ghana	0.8	1.1	1.7	1.7
Ghana	0.6	0.6	0.8	0.9	Togo	1.3	1.7	1.6	1.5
Senegal	0.7	0.9	0.9	0.9	Guinea	0.9	1.2	1.5	1.5
Benin	0.4	0.5	0.5	0.5	Guinea-Bissau	1.3	1.2	1.5	1.5
Sierra Leone	0.6	0.2	0.4	0.4	Benin	0.9	0.9	0.8	0.8
Gambia	0.3	0.3	0.4	0.2	Sierra Leone	0.2	0.3	0.7	0.7
Guinea	0.2	0.2	0.3	0.2	Gambia	0.5	0.9	0.9	0.7
Mali	0.2	0.2	0.2	0.2	Côte d'Ivoire	0.5	0.5	0.6	0.6
Niger	0.1	0.1	0.1	0.1	Liberia	0.5	0.5	0.5	0.5
ECOWAS beef	1.1	1.2	1.2	1.2	ECOWAS sheep	2.4	2.6	2.7	2.6

Source: USDA-ERS, International Macroeconomic Data Set, March 2016.

Table II : ECOWAS populations and annual growth rates

	Population		Annual growth rate	
	1999	2014	1999	2014
	Million		Percent	
Nigeria	120.91	177.16	2.44	2.50
Ghana	18.61	25.76	1.92	2.22
Cote D'Ivoire	16.46	22.85	2.56	2.00
Burkina Faso	11.23	18.37	3.24	3.10
Niger	10.37	17.47	3.36	3.35
Mali	10.48	16.46	2.92	3.05
Senegal	9.25	13.64	2.39	2.52
Guinea	8.15	11.47	3.13	2.67
Benin	6.41	10.16	3.30	2.87
Togo	4.85	7.35	2.91	2.76
Sierra Leone	3.74	5.74	(0.27)	2.33
Liberia	2.50	4.09	6.21	2.57
Gambia	1.32	1.93	2.97	2.26
Guinea Bissau	1.25	1.69	2.30	1.96
Cape Verde Islands	0.42	0.54	2.11	1.41
ECOWAS	225.95	334.67	2.56	2.56

Source: USDA-ERS, International Macroeconomic Data Set, October 2015