THE DYNAMIC IMPACT OF H5N1 AVIAN INFLUENZA ON THE TURKISH POULTRY SECTOR

SAYED H. SAGHAIAN (*)
Department of Agricultural Economics, 314 Charles E. Barnhart Building, University of Kentucky, Lexington, KY 40546-0276, USA.
Phone: 1-859-257-2356.
E-mail: ssaghaian@uky.edu

GÖKHAN ÖZERTAN
Department of Economics, Boğaziçi University, 34342 Bebek, Istanbul, Turkey
Phone: 90-212-359-7645,
E-mail: ozertan@boun.edu.tr

ASLIHAN D. SPAULDING
Department of Agriculture, 132 Ropp Agriculture Building, Illinois State University, Normal, IL 61790-5020, USA.
Phone: 1-309-438-8091
E-mail: adspaul@ilstu.edu

Abstract: This article addresses the dynamic impact of the 2005 *H5N1 Avian Influenza* discovery on the Turkish poultry sector which is heavily influenced by the crisis. Time-series analysis and historical decomposition with monthly farm, wholesale, and retail chicken price series are used to address the dynamics of price adjustment and causality along the Turkish poultry marketing channel. The estimations show that price adjustment is asymmetric with respect to both speed and magnitude. The results also reveal a differential impact of the exogenous shock on producers and retailers, leading to widening of price margins and pointing to imperfect price transmission. Regarding efficiency and equity of the marketing channel our findings are critical, especially at the farm level.

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(*) Corresponding author

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1. Introduction

In recent years, many highly publicized incidents of food safety scares have been reported worldwide. The impact of such events on human health and consumers' safety concerns and their willingness to pay for food safety has received a lot of attention in the literature. An additional important issue is how food safety shocks and their related consumer reactions impact price adjustments across vertically linked markets.

One of these shocks, the Spanish Flu Pandemic (1918 Flu) that occurred at the beginning of the 20^{th} Century resulted in mortalities of somewhere between 50 to 100 million people. Recent research indicates that the 1918 Flu, which is similar to H5N1, could be caused by an avian influenza (also known as avian flu, bird flu, bird influenza) virus (Taubenberger, 2005). The most recent avian influenza epidemic started in January 2004 in Vietnam when the H5N1 virus was observed in humans and poultry. As a consequence, following the spread of the news the European Union (EU) decided to stop its poultry imports. Later on, the EU announced that import restrictions would be removed in May 2005.

The Turkish poultry sector was also heavily affected from the worldwide incidents. The first outbreak of the H5N1 avian influenza in humans was observed in mid-October 2005 in northwestern Turkey, and in January 5, 2006 two fatal cases in humans were experienced. At the end of January the number of fatalities had increased to 4. Following these incidents, poultry producers estimated the worst scenario with shrinkage of the market resulting in a 50-75% decrease in demand and size. This amounted to a loss of 1-1.5 billion USD in 2006 at the same time causing a job destruction of the size of 75,000 workers.

Relatedly, significant decreases are also observed in the sales of domestic feed industry (GAIN, 2005; Harmanyeri, 2006).

The current size of the poultry sector in Turkey is estimated to be around 2.5 billion USD with around 150 million birds commercially traded. The employment figure in the sector is 150,000 people (GAIN, 2005; Harmanyeri, 2006). Production and per capita consumption numbers are presented in Table 1. State Planning Organization projections show that in year 2010 demand in Turkey will reach 1,2 million tons with a per person consumption of 16 kg/year. Respective estimations are 1,5 million tons and 19 kg/year per person for the year 2015. Relative to its size, Turkey's international trade of poultry products is at minor levels. Imports of poultry products in 2004 amounted to a value of 7.4 million USD where the major trading partners were the U.K., Germany, U.S.A and France. In the same year exports were worth of 2 million USD with Romania, Georgia and Azerbaijan being the major importers. Domestic demand for poultry products is almost totally provided by domestic production.

< Insert Table 1 about here>

Comparing Turkey's poultry production with the world, total production in the World was 74 million tons in 2002. Turkey was ranked 25th in the world regarding total poultry meat production in 2002. When only broiler production is considered Turkey's rank improved to 14th in 2004 (World Poultry, 2004). World per capita consumption numbers were 12.2 kg/year both in 2003 and 2004 with the U.S. having 54 kg/year and EU-15 23 kg/year in 2004 (Executive Guide, 2003/4).

During the recent avian influenza crisis, wholesale broiler prices in Turkey dropped to the levels of 1.52 YTL/kg, but soon after, especially with TV ads and newspaper announcements by the state authorities and poultry producers, demand increased, and prices rose to the levels of 2.22 YTL/kg in April 2006. Broiler prices (based on producer prices) for the period January 2003-September 2006 are presented in Figure 1.

< Insert Figure 1 about here>

In this research we investigate the impact of the H5N1 avian influenza on the Turkish poultry sector by focusing on the short-run dynamics of price adjustment and price transmission along the Turkish poultry marketing channel to see whether the safety scare affected the price margins along the supply channel. In recent years food industries have faced notable structural changes and higher market concentration, which brings about the important research question of to what extent the food safety shock in the Turkish poultry sector was transmitted through the supply chain and impacted prices at farm, wholesale, and retail levels. Market concentration and the likely presence of market power can potentially influence the degree and dynamics of price transmission, leading to differential price effects on different stages of the chain. Differing market operation dynamics under competitive and noncompetitive market conditions can also have welfare implications with respect to the efficiency and equity of the marketing system.

To analyze the research problem stated above and to investigate the dynamics of price transmission along the Turkish poultry supply chain we employ a vector error correction (VEC) model along with directed acyclic graphs and historical decomposition. The use of the VEC model not only allows to estimate the short-run speed of adjustment for the price series, at the same time it also preserves the long-run relationships among the variables. With the help of the cointegration analysis we would like to evaluate market efficiency and analyze both perfect and imperfect market conditions. Cointegration of prices in distinct markets is an indication of price transmission and market integration. Its convergence property is consistent with the hypothesis that arbitrage binds prices into a long-run relationship. And lastly, the use of historical decomposition identifies the short-run dynamic effects of the poultry market shock on prices and aids in providing a visual explanation of the impact of the food scare on the price series in the neighborhood of the event.

This paper is organized as follows. In section 2 we provide a review of the literature. Following that, in section 3, information about the empirical model employed and the data used in this research are presented. And finally, in section 4, we convey our interpretations of the results together with our concluding remarks.

2. Literature Review

There are a great number of research articles on market integration and price transmission along the agricultural marketing channels. While prices can be transmitted temporally, vertically, or spatially, the early literature in this area typically focused on farm-retail spreads to analyze rapid producer price changes and how they were passed to consumers. The early models were primarily static linear equilibrium models applied to perfectly competitive markets. An important example of this literature is the work of Gardner (1975). He investigated the factors that influence the price of marketing services and price transmission between farm and retail sectors, focusing on the source of the exogenous shock on supply and demand functions. However, using conventional linear models in a non-linear situation leads to the wrong conclusions. Heien (1980) added dynamic analysis to address short-run disequilibrium price adjustments.

According to price determination theory, producer price changes determine retail price changes; that is, price transmission flows downward along the supply chain and the direction of causality runs from producer to retail prices. However, the empirical results of studies applied to different commodities in different countries regarding this issue are mixed. For example, Tiffin and Dawson (2000) studying the UK lamb market found that lamb prices were determined in the retail market, and then passed upward along the supply chain; that is, the direction of causality is from retail to producer prices. Others found that retail market shocks were confined in retail markets for the most part, but farm markets adjusted to shocks in wholesale markets (Goodwin and Holt, 1999 and Goodwin and Harper, 2000). Yet, Ben-Kaabia, *et al.* (2002) found both supply and demand shocks were fully passed through the marketing channel.

While short-run price behavior is better understood and explained, the longer term movements of margins is not fully understood (Tiffin and Dawson, 2000). Price transmission can be asymmetric when the speed of price adjustment across vertically linked markets is different. Price asymmetry can exist with respect to magnitude or speed, or a combination of the two. In the case of magnitude, long-run elasticities of price transmission differ depending on the direction of the initial price change; in the case of speed, short-term elasticities are different (Luoma, *et al.*, 2004).

The traditional definition of price asymmetry which also affects price margins refers to a situation where producer price rises are moved faster and more completely to consumers than price reductions (Pelzman, 2000; Bakucs and Ferto, 2005). In those cases, the standard Dicky-Fuller unit root tests also used in this study are misspecified and are not efficient in detecting cointegration relationship (Enders and Granger, 1998). In this research we specifically focus on the different speeds of price adjustment along the poultry marketing channel in the farm, wholesale and retail markets affecting price margins in Turkey.

There are many notable developments of price transmission theory in the area of market efficiency and imperfect competition (e.g., Azzam and Pagoulatos, 1990; Holloway, 1991; Hyde and Perloff, 1997, among others). Luoma, *et al.* (2004) has argued that market power is the most likely explanation for asymmetric price transmission in the long run**.** The fact that price dynamics may differ under competitive and noncompetitive market conditions can lead to market inefficiency. McCorriston *et al.* (1998) has demonstrated the role of oligopoly power in determining the price transmission elasticity following a supply shock. Other studies have supported the hypothesis that market concentration and imperfect competition can be the cause of asymmetric price transmission (Miller and Hayenga, 2001; Lloyd, *et al.*, 2003).

Market power can also affect price transmission in opposite ways. In imperfectly competitive markets, retailers may keep price levels relatively fixed for long periods, or oligopolies may react quicker to declining margins by utilizing their market power (Jumah, 2004). The reason they do this is to maintain market shares, keeping long-run rather than short-run profits in mind. Also, Lloyd *et al.* (2003) tested the hypothesis that market power could cause the margin between retail and farm prices to widen. Those results have clear consequences for this study and may be an explanation for the results of this research, considering the fact that the food industries are now faced with notable wholesale and retail market concentration.

3. Data, Econometric Model Development, and Empirical Results

The dataset used in this study was officially collected by the Turkish Statistical Institute (TUIK). Monthly time-series chicken price spreads were assembled for the period 2003:01 to 2006:09 for farm prices $\{P_{ft}\}$, wholesale prices $\{P_{wt}\}$, and retail prices $\{P_{rt}\}$. Data on poultry prices is collected on a monthly basis, whereas prices received by farmers are published by the Department of Agricultural and Environmental Statistics, and the wholesale and retail prices are published by the Department of National Accounts and Economic Indicators (both departments are divisions within TUIK).

Data recorded goes back to 1994, but the base year of the index was changed at the beginning of 2005. Still, data collected before 2005 is compatible with data collected afterwards. All data mentioned above are publicly available. All prices are in Yeni Turk Lirasý (new Turkish currency) per kilogram (YTL/KG) where the average exchange rate for the period analyzed was 1 USD=1.35 YTL. The price series are based on whole chicken. Descriptive statistics of the price series are provided in Table 2. The assumption is that the H5N1 avian influenza reported by the news outlets affects quality perception of all chicken negatively, consistent with other research in food safety scare (e.g., Piggott and Marsh, 2004).

< Insert Table 2 about here>

While the beginning date of the H5N1 avian flu scare is known, there is no way to know exactly how long the impact of the safety scare on consumers' perception of chicken safety can last. In this research we concentrate on the short-run dynamics of price adjustment and price transmission at different market levels in a neighborhood around the H5N1 avian flu shock specified by the historical decomposition graphs, though price transmission patterns could be different before and after the food safety scare.

Given the nature of the underlying data series, we closely follow the contemporary non-stationary time-series modeling. First, the temporal properties of the three price series are analyzed using augmented Dickey-Fuller tests. The null hypothesis is that the series are non-stationary in their levels. Second, Johansen's cointegration tests are employed to determine if a long-run relationship exists among the three price series in the system. Whenever the series are integrated and co-integrated, a VEC Model is appropriate to characterize the multivariate relationships among the variables.

Next, we estimate a VEC model and conduct hypothesis testing within this framework. The VEC model uses both short-term dynamics as well as long-term information. Following that, we utilize directed acyclic graphs to investigate the causal patterns among the variable. Directed graphs allow the errors among the endogenous variables to be incorporated into the forecasted effects of the poultry market shock over time. Finally, historical decomposition of farm, wholesale, and retail-level price-series aids in explaining the behavior of chicken prices due to the H5N1 avian influenza shock.

Previous research indicates that these price series are likely to be nonstationary. Consistent with the literature, we use an augmented Dickey-Fuller (ADF) test to determine the order of integration of each price series. For example, in the retail price series $\{P_{rt}\}$, the usual ADF test statistic is obtained from the α_1 parameter in the regression model $\Delta P_{rt} = \alpha_0 + \alpha_1 P_{rt-1} + \sum_{j=1}^{n} \beta_j \Delta P_{rt-j} + \upsilon_t$, where $H_0 : \alpha_1 = 0$ is tested against

$H_1 : \alpha_1 < 0$ with P_{rt} representing the natural logarithm of observed retail prices.

We started with an over-specified ADF regression where *n*, the number of lags, was relatively large and then employed a battery of lag length diagnostic tests to refine the specification for each univariate series to reach *n = 4* (Enders, 1995). The upper portion of Table 3 summarizes the ADF test results for each variable, while the lower portion catalogues the results for the first difference of each price series. Given a MacKinnon 10% critical value, we failed to reject the null hypothesis of a unit root for these variables with two terms, a constant and a trend. Each series was then first differenced and the ADF regressions were re-estimated with a constant but no trend. In each case, we rejected the null hypothesis of a unit root at the 1% level of significance. These stationarity tests are the same as checking the series for the order of integration to see if their mean and variance change and are not constant over time. When the series are integrated of order one, the series then will be checked for long-run equilibrium or cointegration.

< Insert Table 3 about here>

Johansen's Cointegration Tests and the Vector Error Correction Model

Following Enders (1995), when the series are I(1) processes, the possibility of equilibrium is examined by Johansen's cointegration test using the Eviews (2004) software package. These results are reported in Table 4. Johansen's test is a likelihood ratio (LR) test designed to determine the number of cointegrating vectors in the system or the cointegrating rank *r*; theoretically, the rank *r* can be at most one less than the number of endogenous variables in the model. The LR test in our analysis determines if two cointegrating vectors exist between the three endogenous price series.

< Insert Table 4 about here>

We follow Johansen's testing procedures to specify a cointegration model. Each cointegrating equation contains an intercept and a slope coefficient. At the 10 percent level of significance for the trace test (Johansen and Juselius, 1992), we reject the null hypotheses that $r = 0$ and $r \leq 1$, but we failed to reject the null hypothesis that the cointegrating rank of the system is at most 2 at the 10% level. These results suggest there are two long-run equilibrium relationships between the three price series. The cointegrating vectors provide the foundation to empirically address short-run economic reactions and the speed of adjustments, trends, and long-run equilibria.

A more contemporary approach to quantifying the relationship between I(1) series is to construct a VEC model. The ADF test results suggest that a VEC model is more appropriate than a vector autoregression model (VAR) to characterize the multivariate relationships among the three price series (Engle and Granger, 1987). The VEC model incorporates cointegration to capture the information contained in the series' long run stochastic trend, and reflects the fact that the variables are I(1) and must be differenced. In this model, the first difference of each price series is represented as a function of its own lagged values, the lagged values of the other variables and cointegrating equations. The specification of the VEC model used to conduct the analysis is as follows:

$$\Delta P_t = \alpha_0 + \sum_{i=1}^{k-1} \Gamma_i \Delta P_{t-i} + \prod P_{t-k} + \varepsilon_t$$

where ΔP_t is a (3x1) matrix ($\Delta P_{1t}, \Delta P_{2t}$ and ΔP_{3t} represent the three price series); α_0 is a (3x1) vector of intercept terms; the $\Gamma_i \Delta P_{t-i}$ terms reflect the short-run relationships among elements of the P_t matrix, and the $\prod$ matrix captures the long-run relationship among the variables. The $\prod$ matrix can be decomposed into two $p \times r$ matrices, α and β, where $\prod = \alpha\beta'$. The matrix β contains the co-integrating vectors that represent the underlying long-run relationship and the α matrix describes the speed of adjustment at which each variable moves back to its long run equilibrium after a temporary shock or departure from it (Johansen and Juselius, 1992; Schmidt, 2000).

The stability of the dynamic VEC model is an important issue that needs to be addressed. We have to make sure the dynamic model is stable and the adjustment paths converge to the long-run equilibrium as time passes. The VEC model is stable if all the characteristic roots have modulus less than one and lie inside the unit circle. If the model is unstable, the empirical results are not valid and long-run steady-state equilibrium does not exist. For our date the results show that the dynamic model is stable and all the characteristic roots are within the unit circle. As expected, we found no evidence of first-order autocorrelation at the 5 percent level of significance using the Durbin-Watson bounds test. The R^2 values indicate that between 24 to 46 percent of the variation in the natural logarithms of the price series are explained by the models.

Dynamic speeds of adjustment

The VEC model analysis of dynamic adjustments permits this study to provide a precise measure of the speeds of price transmission. The empirical estimates of the speeds of adjustment are summarized in the top portion of table 5. Whereas the speeds of adjustment for the farm and retail price series were statistically significant at the 1% level, the speed of adjustment for the wholesale prices was not statistically significant. The dynamic speed of adjustment for the retail prices was higher (0.77), in absolute value, than farm prices (0.59), an indication of asymmetric price transmission with respect to speed. This is an interesting result suggesting that with the safety shock, retail prices adjust more quickly and are more flexible than farm prices to restore the long run equilibrium.

This is an important result for policy makers and agribusinesses and has clear implications for the efficiency and equity of the Turkish poultry marketing system. These results indicate that the speeds of price adjustment are not the same in different markets and prices in the retail market adjust more quickly than prices at the farm level in response to the safety shock. Because retail prices decrease faster than farm prices, the burden of the H5N1 virus shock is borne more by the retailers than farmers. As a result, the farm-retail price margins are widened.

A H5N1 virus shock is hypothesized to affect consumers' perception of chicken quality negatively and is anticipated to cause spot chicken prices to decrease. It also leads to the anticipation of price decreases in the futures market. If we assume a perfect competitive market condition such as an auction market with perfect information and no adjustment costs or explicit contracts, then prices should be flexible and adjust quickly and fully in response to the H5N1 virus scare; the shock, as expected, induces an immediate decrease in spot prices.

These results might be a signal of more concentration and market power at the farm level. In an efficient market condition, prices are transmitted fully and completely. The fact that price dynamics differ point to noncompetitive market conditions that can lead to market inefficiency. It is important to note that our analysis cannot directly test for imperfect competition and does not address the issue of concentration and market power explicitly. Future research and modeling efforts are required to address this hypothesis directly and appropriately.

The results seem to indicate that the retail poultry market is more competitive and operates more efficiently compared to the farm level, suggesting there might be higher degree of concentration at the farm level. That is, these results support the hypothesis that there is higher concentration and imperfectly competitive behavior at the farm level. Karp and Perloff (1993) have shown, however, that the dynamic behavior of oligopolies is relatively more competitive than collusive. Our result shows the retail chicken prices to be relatively more 'flexible', drawing attention to concentration and imperfect competition at the farm level. Prices of most commodities which are homogeneous and are traded in auction markets adjust instantaneously in response to exogenous shocks and fall under this category.

Some explanations given in the literature for the causes of price asymmetry are product heterogeneity, long term contracts, and adjustment or menu costs (e.g., Goodwin and Holt, 1999; Zachariasse and Bunte, 2003), which may explain the differential speeds of price adjustment along the Turkish poultry marketing channel. Originally, Hicks (1974) and Okun's (1975) works showed that prices in some sectors of the economy were sticky while prices in other sectors were flexible. According to their arguments, prices of most goods and services are not free to respond to changes in demand in the short run. This is due to imperfect information, costs of changing prices, explicit contracts, etc. Most prices of manufacturers and services and in general, heterogeneous goods fall under this category.

Causality and directed graphs

We use the covariance matrix of the VEC model to investigate the causal relationship among the variables by directed acyclic graphs (Bessler and Akleman, 1998). A directed graph is a picture representing the causal flow among a set of variables called nodes. Lines with arrowheads are used to represent causal directions so that an arrowhead from node A to node B means variable A causes variable B. A connecting line with no arrowhead indicates the two variables are connected by information flow, but we cannot say which one causes the other. An algorithm is utilized which first assigns undirected lines to all the nodes (variables) and then removes adjacent edges when partial correlations are not statistically significant and determines causal flow directions for the remaining edges based on the partial correlations of the residuals (Spirtes, *et al.*, 2000). The TETRAD IV software (Spirtes *et al.*, 1999) is used to generate the causal patterns among the price series. Figure 2 presents the causal structure of the three price series on innovations from the three variables generated by the TETRAD software at the 5% significance level. The results show that innovations in farm and wholesale and in wholesale and retail price variables affect residuals in each other (i.e., there is a connecting edge), but there are no arrows to indicate direction of causality. According to the TETRAD software, this is a case where an edge between A and B indicates that either A is a cause of B or B is a cause of A, or there is a common latent cause of A and B, or some combination of these, but the direction of causality is not known given the nature of residuals at hand. Also, there exists no residual relationship between farm and retail prices; the relationship between farm and retail price residuals is through wholesale prices.

< Insert Figure 2 about here>

Historical decomposition graphs

Earlier we discovered that the speeds of price adjustment along the Turkish chicken supply varied in response to the H5N1 virus scare. The next important step is that of measuring the magnitude of price transmission due the food safety shock, which can be handled by historical decomposition graphs. Historical decompositions based on causal patterns decompose the price series of the structural VEC model to determine the impact of the safety shock on prices in a neighborhood (time interval) of the safety scare. Historical decomposition graphs are based upon partitioning of the moving average series into two parts:

$$P_{t+j} = \sum_{s=0}^{j-1} \psi_s U_{t+j-s} + \left[X_{t+j}\beta + \sum_{s=j}^{\infty} \psi_s U_{t+j-s} \right]$$

where P_{t+j} is the multivariate stochastic process, U is its multivariate noise process, and X is the deterministic part of P_{t+j}. The first sum represents that part of P_{t+j} due to innovations (shocks) that drive the joint behavior of chicken prices for period $t+1$ to $t+j$, the horizon of interest, and the second is the forecast of price series based on information available at time *t*, the date of an event—that is, how prices would have evolved if there had been no shocks (RATS, 2004).

Figure 3 shows the historical decomposition graphs of the three price series for a four month horizon from RATS software. The solid line is the actual price which includes the impact of the H5N1 shock and the dashed line is the forecast of that price excluding the effect of any shock. The dynamic impacts of the shocks can spread over many time periods or dissipate quickly. However, we don’t look at prices very far into the future because we are more interested in the contemporaneous nature of their impacts. Further, it is likely that other effects would normally occur after a few weeks or months to cloud their impacts. For this study we have used a seven month time-period for forecasting and testing the impact of the H5N1 virus shock.

< Insert Figure 3 about here>

The H5N1 virus was discovered in October, 2005. Before this date, the actual farm, wholesale and retail prices (solid lines) and their forecast prices (dashed lines) followed each other closely with minor differences that are commonly expected between actual price and its forecast. However, they began to depart significantly in October 2005. Historical decomposition of the retail prices which includes the impact of the shock showed that the wide departure of actual retail prices occurred in October and reached its maximum by the beginning of November 2005. It is estimated that the retail prices dropped by 38% in November 2005 compared with the prices in September of 2005. In November 2005, the estimated magnitude of the actual retail prices with the impact of the food safety scare were 18% lower than the forecast prices without the shock.

Meanwhile the sharp fall in wholesale prices during the same time period was also estimated to be about 38%, indicating that the retail and wholesale prices were mimicking each other closely. However, the difference between the actual (solid line) and the forecast wholesale prices (dashed line) at the beginning of November 2005 was estimated to be about 28%. In contrast, the negative impact of the bird flu shock on the farm prices during October of 2005 was estimated to be only about 20%. These results, consistent with the results for speeds of adjustment, show that the chicken-safety scare impacts on producers and retailers are quite different. The impact of the shock on the retail and wholesale prices is almost twice as much of the impact on the farm prices, a clear indication of asymmetric price effect with respect to magnitude. These results clearly indicate that in the short run, an exogenous food safety scare on the Turkish poultry sector impacted wholesalers and retailers much more severely than producers.

Interestingly, between October and November of 2005, farm prices recovered up to a point where the actual and forecast prices were the same in November, but farm prices kept on decreasing for the next few months with the continued media coverage of the bird flu and the news of fatalities. The wholesale and retail prices were also shown to increase by December with one month lag and level off again, but during the period of February and March, they had completely recovered and had a sharp increase by April 2006. There are several reasons for this behavior: First, the result is related with the preferences and habits of Turkish consumers. Seasonality in poultry consumption is significant in Turkey where demand for poultry meat increases in early Spring with increased outdoor activities and picnicking/grilling. A second reason is that there was a suppressed demand for poultry during the crisis and once the crisis was over, demand for poultry meat increased while companies had allegedly destroyed chicks they owned and cancelled the contracts they had signed with growers, suppressing their supply. Also, during the crisis, due to excess financial pressure several small sized producers went bankrupt and exited the market (Yalçın, 2006).

Overall, the historical decomposition results showed, as expected, that the H5N1 virus discovery impacted chicken prices negatively, but the magnitudes of price effects were substantially different for the price series, resulting in widening of the price margins. Also, the effect of the shock on the wholesale and retail price series in December had about a one month lag. Since the H5N1 virus discovery was covered by the media and electronic news outlets rather quickly, the estimated one month lag of the safety impact along the supply channel may reflect the role of contracts and the fact that in this research we are dealing with monthly data series, rather than reflecting problems with the flow of information through the chain.

These results, consistent with our previous results regarding the differentials speeds of adjustment, suggest differing price transmission in the Turkish poultry marketing channel. Lloyd *et al.* (2003), who investigated the impact of food scare in the UK meat market, suggested that market power could influence the retail-farm margin. Their results supported the hypothesis that market power caused the margin between retail and farm prices to widen following a food safety scare. Our results also point to the existence of market inefficiency, and might be a signal of market concentration and oligopsony behavior at the farm level in the Turkish poultry sector as well, because farm prices had lower speed of adjustment and also fell less than retail prices due to the shock. More research which explicitly incorporates appropriate imperfect competitive and marker power analysis is required in order to address the oligopolistic and oligopsonistic market behavior in the Turkish poultry sector.

4. Summary and Concluding Remarks

In this article we investigated how the late 2005 H5N1 virus discovery in the Turkish poultry sector affected farm, wholesale, and retail level chicken price series along the Turkish chicken supply channel. We applied time-series cointegration techniques, vector error correction, directed graphs, and historical decomposition to monthly Turkish chicken price series. The objective was to investigate a few fairly important hypotheses.

First, one hypothesis is that high concentration leads to asymmetric price transmission and market inefficiency at the farm, wholesale, and/or retail levels. The results of the cointegrated VEC model showed that retail prices were more flexible than farm prices, and the short-run speed of adjustment at the retail level was faster than the one at the farm level, pointing to a relatively higher degree of imperfect price transmission at the farm level. Hahn (2004), investigating the U.S. meat markets, argues that month-to-month meat price changes are due to dynamic adjustments; he showed that livestock and meat prices vary more in the short run than operation costs. Mathews, Jr. *et al.* (1999) argue that wholesale prices have more variability than retail prices in the U.S. beef sector. They further state that it often seems that retail prices follow producer prices and mimic the ups and downs of producer prices with lags of a month or more. Our results confirmed this assertion to a degree. We also used monthly data and historical decomposition graphs showed the lag to be about one month for part of the time-period investigated.

Second, the historical decomposition results corroborated the results of the VEC model and dynamic speeds of adjustment showing the burden of the H5N1 virus shock was distributed unevenly, with the wholesale and retail levels taking most of the burden of the negative shock, falling by almost twice as much compared to the fall in the farm prices. However, Azzam and Anderson (1996), who reviewed the literature on meatpacking industry in the U.S., concluded that packers' market power did not increase with higher concentration and argued that increased concentration might be due to the economies of size rather than noncompetitive behavior.

The differential effects of the H5N1 virus discovery on the supply channel widen the gross margins between farm and wholesale and wholesale and retail and consequently distort distribution of income in this industry. These results suggest that the Turkish poultry marketing system is hampered with inefficiency and in order to address market inefficiency in the Turkish poultry sector, one must draw attention to the producer market. The problem may be concentration and oligopsony power at the farm level. Further research is needed to address these issues.

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