# Modeling *Ex Ante* Price Expectations within the U.S. Broiler Market

by

Andrew McKenzie and Matthew T. Holt

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A statistically optimal inference about market agents' *ex ante* price expectations within the U.S. broiler market is derived using futures prices of related commodities in conjunction with a quasi-rational forecasting regression equation. Specifically, the relationship between the variances and covariances among broiler cash prices, and spot and futures prices of related commodities are exploited. The relationship between movements in the relevant cash price series and movements in related futures prices allows us to decompose changes in the expected cash price series into anticipated and unanticipated components. This modeling approach follows closely the work of Hamilton (1992), and allows us to determine the relative importance of various informational sources in the formation of broiler price expectations. The modeling framework is extended beyond that considered by Hamilton in that production is added to the model. As such, this is the first known attempt to endogenize supply response using futures prices within a quasi-rational expectations framework. Both the true supply shock and *ex post* broiler price forecast errors were found to have a small but significant influence on *ex ante* price expectations. The quasi-rational forecasting regression, however, captured most of agents' *ex ante* price expectations over the sample period.

## Introduction

There is no definitive theoretical or empirical model of price expectations that can be considered optimal for modeling agricultural supply response. A vast array of approaches have been used, ranging from past prices through the use of futures prices [Gardner 1976] and prices derived from rational expectations models [Goodwin and Sheffrin 1982]. However, past research has almost exclusively used each approach as if they were independent and separate from each other. The modeling approach taken in this paper is unique in that it recognizes that a combination of informational sources may more accurately reflect market agents' true price expectations. The main objective of this paper is to model the historical price expectations of market agents within the U.S. broiler market over the period 1966-95. Specifically, statistically optimal inferences about market agents' price expectations are obtained. The statistical inferences of these expected prices are then subsequently used to estimate the producer supply response. This study uses futures market prices in combination with other relevant information, such as lagged cash prices, to obtain expected prices for the relevant inputs and substitute goods used in broiler production decisions. Loosely speaking the correlation between these futures prices and the forecasted output price of wholesale broilers is then exploited to obtain results as to whether futures prices actually contribute information, above and beyond that contained in a quasi-rational forecasting regression, to agents' price expectations.

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In the next section the theoretical approach for modeling broiler price expectations is developed. The second section discusses the data and the model is specified. The third section presents the empirical results and a final section discusses conclusions.

## Theoretical Model of Broiler Price Expectations

This section develops a model of the relationship between commodity prices and broiler prices. Let $p_t$ denote the cash market price of broilers and let $\underline{x}_{t-1}$ represent a subset of the information set that agents use to forecast broiler prices. A quasi-rational forecasting regression may then be written in first difference form as (1), to be consistent with the data, where $\Delta$ is the difference operator.

$$(1) \qquad \Delta p_t = \underline{\tilde{b}}' \Delta \underline{x}_{t-1} + u_t$$

Inferences about agents' expectations may be made by estimating equation (1) by, for example, ordinary least squares (OLS). The fitted values could then be assumed to represent agents' true expectations of broiler prices, $\hat{p}_t^e$:

$$(2) \quad \hat{p}_t^e = p_{t-1} + \underline{\tilde{b}}' \underline{x}_{t-1}$$

Following Hamilton (1992), a representative agent's true forecast may be assumed to have differed from (2) by a term $\alpha_{t-1}$.

$$(3) \qquad p_t^e = p_{t-1} + \underline{\tilde{b}}' \Delta \underline{x}_{t-1} + \alpha_{t-1}$$

If the rational expectations assumption holds, $\alpha_{t-1}$ represents information agents had in addition to $\underline{x}_{t-1}$ that was useful for forecasting $p_t$, but which could not be observed by an econometrician. Let $a_t$ denote the *true* error agents made in forecasting the broiler price in period t:

$$(4) \qquad a_t \equiv p_t - p_t^e$$

It then follows that:

$$(5) \qquad u_t = \alpha_{t-1} + a_t$$

The two terms-- $\alpha_{t-1}$, the omitted information term, and the idiosyncratic error term $a_t$, which is the true forecast error—are thus subsumed in the composite error term, $u_t$. As is typical in the REH, it is assumed that $\underline{x}_{t-1}$ includes enough explanatory variables and lags of $p_t$ to render $u_t$ to be white noise. In other words $u_t$ is uncorrelated with its own past values. Under the assumption of rational expectations, agents' true forecasting error must also be white noise and uncorrelated with $\alpha_{t-1}$. Following Hamilton (1992), it is further assumed that $\alpha_{t-1}$ is a white noise process, which is also consistent with rational expectations. The information contained in related commodity futures prices is used to draw inferences on what is contained in the omitted information term $\alpha_{t-1}$, and hence to obtain an inference of agents' true broiler price expectations.

Let $\sigma_a^2$ denote the variance of agents' true forecasting error $\left(\sigma_a^2 = E\left[a_t^2\right]\right)$ and let $\sigma_\alpha^2$ denote the variance of the omitted information term $\left(\sigma_\alpha^2 = E\left[\alpha_{t-1}^2\right]\right)$. Assuming that $\alpha_{t-1}$ and $a_t$ are independently distributed, then the variance of the observed OLS residual can be viewed as the sum of these two independent terms.

$$E\left[u_t^2\right] = \sigma_\alpha^2 + \sigma_a^2$$

Next consider the commodity futures markets. The error each market made in forecasting its nominal spot price, $S_{j,t}$, after adjusting for short–run or transitory inefficiencies, is denoted as $v_{j,t}$. This error term is observed from expression (7), which shows the systematic relationship between futures prices and their respective spot prices based on relevant information contained in the information set $\underline{\tilde{\pi}}_{t-1}$.

$$\text{(7)} \qquad \Delta S_{j,t} = \tilde{\beta}_j' \Delta \underline{\tilde{\pi}}_{t\cdot} + v_{j,t}$$

The error term $v_{j,t}$ represents the forecast error made by rational agents, by using all available information at time $t-1$, in predicting future spot price changes in period $t$. Consider the projection of this error on the true wholesale broiler price forecast error observed from (4) above:

$$\text{(8)} \qquad v_{j,t} = q_j^a a_t + e_{j,t}$$

where $e_{j,t}$ denotes unanticipated movements in the price of each commodity that are uncorrelated with movements in wholesale broiler prices. The covariance between the observed wholesale broiler price forecast error $u_t$ and the observed commodity price forecast error $v_{j,t}$ is then given by:

$$\text{(9)} \qquad E\left[u_t v_{j,t}\right] = E\left[\left(\alpha_{t-1} + a_t\right)\left(q_j^a a_t + e_{j,t}\right)\right] = q_j^a \sigma_a^2$$

That is, under rational expectations any covariance between $u_t$ and $v_{j,t}$ must be due to $a_t$, market agents' true error in forecasting wholesale broiler prices. If not, and if the rational commodity forecast error is also correlated with $\alpha_{t-1}$, then participants in the futures markets could have exploited this information from the broiler market to improve their forecasts of expected spot prices in other related commodity markets. Thus the covariance between the quasi-rational broiler forecasting regression error term and the rational commodity price forecast error is expressed purely in terms of the true forecast error, and hence *unanticipated* movements in commodity spot prices can only be related to *unanticipated* movements in broiler prices.

Next, consider a regression of the commodity futures prices, $f_{j,t-1}$, on the information set $\underline{\phi}_{t-1}$, where $\underline{\phi}_{t-1}$ denotes a subset of the information set $\underline{x}_{t-1}$:

$$(10) \quad \Delta f_{j,t-1} = \widetilde{d}_j' \Delta \underline{\phi}_{t-1} + \upsilon_{j,t-1}$$

Expression (10) reflects the fact that futures prices are endogenized within the model. The term $\upsilon_{j,t-1}$ reflects information that market agents had beyond that contained in $\underline{\phi}_{t-1}$ that was useful in determining actual future market prices. It is assumed that $\underline{\phi}_{t-1}$ contains sufficient explanatory variables (and lags of explanatory variables) so as to render $\upsilon_{j,t-1}$ to be white noise. Any correlation between the quasi-rational broiler forecasting regression error term $u_t = (\alpha_{t-1} + a_t)$ and the futures price error term $\upsilon_{j,t-1}$ must be attributed to $\alpha_{t-1}$ – the omitted information term. This is because these two terms represent information known by agents' at time $t-1$, and can be thought of as shared information about the co-movement of prices within the meat/feed grain complex.
Consider then the projection of $\upsilon_{j,t-1}$ on $\alpha_{t-1}$:

$$\upsilon_{j,t-1} = q_j^{\alpha} \alpha_{t-1} + \varepsilon_{j,t-1}$$

where $\varepsilon_{j,t-1}$ denotes information agents had at time $t-1$ about the future price changes of commodities, which are in turn uncorrelated with wholesale broiler price movements. The covariance between the observed OLS wholesale broiler price prediction error $(u_t)$ and the observed commodity regression forecast error $(\upsilon_{j,t-1})$ is given by:

$$E[u_t \upsilon_{j,t-1}] = E[(\alpha_{t-1} + a_t)(q_j^{\alpha} \alpha_{t-1} + \varepsilon_{j,t-1})] = q_j^{\alpha} \sigma_{\alpha}^2$$

Thus, under rational expectations it is assumed that *anticipated* movements in broiler prices, can only be related to *anticipated* movements in related commodity prices, which are captured by futures prices.

The covariance between the observed commodity price forecast error $v_{j,t}$ and the observed commodity regression error $\upsilon_{j,t-1}$ is given by:

$$E[v_{j,t} \upsilon_{j,t-1}] = E[(q_j^{a} a_t + e_{j,t})(q_j^{\alpha} \alpha_{t-1} + \varepsilon_{j,t-1})] = \varphi$$

where $\varphi = E[e_{j,t}\varepsilon_{j,t-1}]$

Hamilton's (1992) model is extended by adding broiler production to the model, and as such it is the first known attempt to endogenize supply response using futures and spot prices of related commodities within a quasi-rational expectations framework. A typical supply equation for broilers is given by:

$$Q_t = \underline{\theta}_1' \underline{R}_t + \theta_2 p_t^e + \eta_t,$$

where $Q_t$ denotes the production of ready to cook young chickens. The term $\underline{R}_t$ represents a vector of relevant exogenous and predetermined variables deemed necessary to model the dynamics of broiler production. The expected price of broilers is given by $p_t^e$. Supply response is measured by the parameter $\theta_2$, which is the supply elasticity. Substituting (3) into (14) gives:

$$(15) \quad Q_t = \underline{\theta}_1' \underline{R}_t + \theta_2 (p_{t-1} + \underline{\tilde{b}}' \Delta \underline{x}_{t-1}) + \theta_2 \alpha_{t-1} + \eta_t$$

Let the error term in (15) be called $\kappa_t$, so that $\kappa_t = \theta_2 \alpha_{t-1} + \eta_t$. In this case the unobserved information rational market agents' possess about expected broiler prices, reflected in the term $\theta_2 \alpha_{t-1}$, is subsumed within the supply equation error term. Thus the supply error term is decomposed into a component known by agents, $\theta_2 \alpha_{t-1}$, and the true supply shock, $\eta_t$. In drawing inferences about $\alpha_{t-1}$, the supply error term is thus incorporated into the statistically optimal inference of expected prices, which is unique to this particular modeling approach. It is also assumed that $\alpha_{t-1}$ is uncorrelated with $\eta_t$, the true supply shock. If not, under the assumption of rational expectations the information available to agents at time $t-1$ on price expectations could have been used to reduce the supply shock in time $t$. By proceeding as before expressions for the covariance between the supply error term and each of the error terms from the various equations in the system, which were previously defined, can be derived.

Consider the projection of the broiler supply equation error $\eta_t$, on the agents' actual broiler price forecast error $a_t$.

$$\eta_t = q^\eta a_t + \zeta_t$$

where $\zeta_t$ denotes unanticipated movements in broiler production that are uncorrelated with movements in wholesale broiler prices. As such, the covariance between the observed wholesale broiler price forecast error, $u_t$, and the observed endogenous broiler supply equation error, $\kappa_t$, which contains the unobserved agents' information about expected prices, is given by:

$$
\begin{aligned}
E[\kappa_t u_t] &= E[(\theta_2\alpha_{t-1} + \eta_t)(\alpha_{t-1} + a_t)], \\
&= E[\theta_2\alpha_{t-1}^2 + \eta_t\alpha_{t-1} + (q^\eta a_t + \zeta_t)a_t], \\
&= \theta_2\sigma_\alpha^2 + q^\eta\sigma_a^2.
\end{aligned}
$$

Next, consider the variance of the observed endogenous broiler supply equation error $\kappa_t$, which includes the unobserved information on agents' price expectations. By definition we have:

$$
E[\kappa_t^2] = E[(\theta_2\alpha_{t-1} + \eta_t)(\theta_2\alpha_{t-1} + \eta_t)] = \theta_2^2\sigma_\alpha^2 + \sigma_\eta^2,
$$

where $\sigma_\eta^2 = E[\eta_t^2]$. Recall that $\sigma_\eta^2$ is the variance of the broiler supply equation error term that does not include agents' information about expected broiler prices. In other words, it is the variance of pure or true production or supply shocks.

As before the commodity futures market's errors in forecasting nominal spot prices are represented by the term $v_{j,t}$, and that the projection of this error on the wholesale broiler price forecast error is given by equation (19),

$$
v_{j,t} = q_j^a a_t = e_{j,t}.
$$

The covariance between the endogenous broiler supply equation error $\kappa_t$ and the commodity forecast error $v_{j,t}$ is given by:

$$
\begin{aligned}
E[\kappa_t v_{j,t}] &= E[(\theta_2\alpha_{t-1} + \eta_t)(q_j^a a_t + e_{j,t})], \\
&= E[(\theta_2\alpha_{t-1} + q^\eta a_t + \zeta_t)(q_j^a a_t + e_{j,t})], \\
&= q^\eta q_j^a \sigma_a^2 + \underline{C}_s
\end{aligned}
$$

where $\underline{C}_s = E[\zeta_t e_{j,t}]$, which is the covariance between (a) unanticipated movements in broiler production that is uncorrelated with movements in broiler prices, and (b) unanticipated movements in related commodity prices that are uncorrelated with movements in broiler prices. Finally, the covariance between $\kappa_t$ and $v_{j,t-1}$ is given by:

$$
\begin{aligned}
E[\kappa_t v_{j,t-1}] &= E[(\theta_2\alpha_{t-1} + q^\eta a_t + \zeta_t)(q_j^\alpha \alpha_{t-1} + \varepsilon_{j,t-1})], \\
&= \theta_2 q_j^\alpha \sigma_\alpha^2 + \underline{C}_q.
\end{aligned}
$$

wherein $\underline{C}_q = E[\zeta_t \varepsilon_{j,t-1}]$ is the covariance between (a) unanticipated movements in broiler production that is uncorrelated with movements in broiler prices, and (b) information agents had about the future price of related commodities that is uncorrelated with broiler prices.

To summarize, a broiler model that includes endogenous expectations of price in the supply equation is formulated by the following system of $2n+2$ equations:

$$
\begin{aligned}
\Delta p_t &= \underline{\tilde{b}}'\Delta \underline{x}_{t-1} + u_t, \\
\Delta f_{j,t-1} &= \tilde{d}_j'\Delta \underline{\phi}_{t-1} + \upsilon_{j,t-1}, \\
\Delta S_{j,t} &= \tilde{\beta}_j'\Delta \underline{\tilde{\pi}}_{t-1} + \nu_{j,t}, \\
Q_t &= \underline{\theta}_1'\underline{R}_t + \theta_2(p_{t-1} + \underline{\tilde{b}}'\Delta \underline{x}_{t-1}) + \kappa_t,
\end{aligned}
$$

where the following are (4 x 1) vectors: $\underline{\upsilon}_{t-1}$; $\underline{\nu}_t$; $\underline{\varepsilon}_{t-1}$; $\underline{e}_t$; $\underline{q}^\alpha$; $\underline{q}^a$; $\underline{C}_q$; $\underline{C}_s$ and $\Sigma \equiv E\left[\underline{\varepsilon}_{t-1}\underline{\varepsilon}_{t-1}'\right]$ ; $S \equiv E\left[\underline{e}_{t-1}\underline{e}_{t-1}'\right]$ ; and $\varphi = \left[e_{j,t}\varepsilon_{j,t-1}\right]$ are (4 x 4) matrices. Then from (6), (9), (12), (22), (23), (24) and (25) the variance-covariance matrix of the observed error terms is:

$$
\Omega \equiv E\begin{bmatrix} u_t \\ \underline{\upsilon}_{t-1} \\ \underline{\nu}_t \\ \kappa_t \end{bmatrix}\left[u_\tau \quad \underline{\upsilon}_{\tau-1} \quad \underline{\nu}_\tau \quad \kappa_\tau\right]
$$

$$
= \begin{cases}
\begin{bmatrix}
(\sigma_a^2+\sigma_\alpha^2) & \sigma_\alpha^2(\underline{q}^\alpha)' & \sigma_a^2(\underline{q}^a)' & (\theta_2\sigma_\alpha^2 + q^\eta\sigma_a^2) \\
\sigma_\alpha^2(\underline{q}^\alpha) & \left[\sigma_\alpha^2\underline{q}^\alpha(\underline{q}^\alpha)' + \Sigma\right] & \varphi & \theta_2\sigma_\alpha^2\underline{q}^\alpha + \underline{C}_q \\
\sigma_a^2 q^a & \varphi' & \left[\sigma_a^2\underline{q}^a(\underline{q}^a)' + S\right] & \sigma_a^2 q^\eta\underline{q}^a + \underline{C}_s \\
\theta_2\sigma_\alpha^2 + q^\eta\sigma_a^2 & \theta_2\sigma_\alpha^2(\underline{q}^\alpha)' + \underline{C}_q' & \sigma_a^2 q^\eta(\underline{q}^a)' + \underline{C}_s' & \theta_2^2\sigma_\alpha^2 + \sigma_\eta^2
\end{bmatrix} & \text{if } t=\tau \\
0 & \text{if } t\neq\tau
\end{cases}
$$

Equations (22)-(26) represent the relevant first and second moments of a stochastic dynamic multiple equation regression model which may be used to infer agents' true beliefs about broiler price movements. Identification of the individual parameters of the matrix $\Omega$ is achieved by restricting, $\underline{q}^a = \underline{q}^\alpha = \underline{q}$. This identifying assumption implies that broiler price shocks are associated with shocks in related commodity prices of the same magnitude.

Likelihood ratio specification tests indicate that the model may be specified subject to the identifying restrictions assumption and the restriction that $\underline{C}_q = 0$.

If it is assumed that the data follow a multivariate Gaussian normal distribution, the conditional expectation of broiler prices given the information set $\underline{x}_{t-1}$ can be written as:

$$\text{(27)} \quad \hat{p}_t^e = p_{t-1} + \underline{\widetilde{b}}' \Delta \underline{x}_{t-1} + (\widetilde{\varpi})\left[p_t - p_{t-1} - \underline{\widetilde{b}}' \Delta \underline{x}_{t-1}\right] + (\underline{\widetilde{\gamma}})\left[\underline{f}_{t-1} - \underline{f}_{t-2} - \widetilde{d}' \Delta \underline{\phi}_{t-1}\right]$$
$$- (\underline{\widetilde{\phi}})\left[\underline{S}_t - \underline{S}_{t-1} - \widetilde{\beta}_j' \Delta \underline{\widetilde{\pi}}_{t-1}\right] + (\widetilde{\delta})\left[\underline{Q}_t - \underline{\theta}_1' \underline{R}_t - \theta_2 (p_{t-1} + \underline{\widetilde{b}}' \Delta \underline{x}_{t-1})\right]$$

Expression (27) is the best unbiased predictor of broiler prices in a mean square error sense and as such may be regarded as a statistically optimal inference of agents *ex ante* broiler price expectations. Although expression (27) has no analytical solution, the parameters $\widetilde{\varpi}, \underline{\widetilde{\gamma}}, \underline{\widetilde{\phi}}$ and $\widetilde{\delta}$ which are linked to the model variance-covariance parameters and to the supply elasticity parameter, $\theta_2$, in (25) can be solved numerically. The first term, $p_{t-1} + \underline{\widetilde{b}}' \Delta \underline{x}_{t-1}$ is the econometrician's prediction from the quasi-rational forecasting regression alone. The four remaining terms represent the various components which make up the inference on $\alpha_{t-1}$. In fact they are simply the weight placed on each of the error terms from the system of equations in (22) – (25). At first blush it may seem odd to include terms in $\hat{p}_t^e$ which contain information only available after the time forecasts were made, such as $p_t$ and $\underline{S}_t$, but this information allows the econometrician to make *ex post* inferences about the *ex ante* value of $\alpha_{t-1}$.

## Data Considerations and Model Specification

A bi-monthly model of the U.S. broiler market is estimated for the period 1966 to 1995. Data used in the model include monthly average cash prices and bi-monthly average production variables from the broiler market along with cash and two-month-ahead futures prices from four commodity markets: live cattle, live hogs, corn and soybean meal. These four commodities are taken to represent the relevant substitutes and inputs for broilers. All variables are transformed by taking natural logarithms and multiplying by one hundred. The two-month forecast horizon was analyzed to match the final grow-out stage of the production cycle for broilers. In order to reduce the error terms $u_t$, $\underline{\upsilon}_{t-1}, \underline{v}_t$ and $\kappa_t$ to white noise, it is necessary to find the set of relevant explanatory variables to be included in the information sets $\underline{x}_{t-1}$, $\underline{\phi}_{t-1}$, $\underline{\widetilde{\pi}}_{t-1}, \underline{R}_t$ from (22), (23), (24) and (25), respectively. Unit root tests indicated that the price series are nonstationary, and equations (22), (23) and (24) were specified as error correction models. The quasi-rational forecasting regression equation (22), is estimated by including lagged broiler prices, lagged corn and soybean meal spot prices, lagged values of chicks hatched, and an error correction term. Lag orderings are largely the result of preliminary testing. The error correction term is derived from a cointegrating vector of broiler, cattle, hog, corn, soybean meal and turkey cash prices[1]. The supply equation (25), estimated in the levels of the data, includes the expected wholesale price of broilers, seasonal dummies, lagged values of broiler chicks hatched and feed cost prices. The lag orders for chicks hatched and feed costs were determined on the basis of prior knowledge of biological lags in broiler production and preliminary testing. Also, an eighth-order lag structure on broiler production is included to account for short-term and intermediate-term dynamics in broiler production.

Final model specifications for the ten equations (22)-(25) are:

$$\Delta pb_t = a_1 \Delta pb_{t-1} + a_2 \Delta pb_{t-2} + a_3 \Delta pc_{t-1} + a_4 \Delta pc_{t-2} + a_5 \Delta psm_{t-1} + a_6 \Delta psm_{t-2}$$

$$+ a_7 \Delta ha_{t-1} + a_8 \Delta ha_{t-2} + a_9 \Delta ha_{t-3} + a_{10} \Delta ha_{t-4} + a_{11} \Delta ha_{t-5} + a_{12} \Delta ha_{t-6}$$

$$+ a_{13} \Delta ha_{t-7} + \rho_1 z_{1,t-1} + u_t$$

$$\Delta lcf_t = b_0 + \sum_{i=1}^{5} b_i D_i + b_6 \Delta plc_{t-1} + b_7 \Delta plc_{t-2} + b_8 \Delta plc_{t-3} + b_9 \Delta plc_{t-4}$$

$$+ b_{10} \Delta plc_{t-5} + b_{11} \Delta plc_{t-6} + b_{12} \Delta lcf_{t-2} + b_{13} \Delta lcf_{t-3} + b_{14} \Delta lcf_{t-4} + b_{15} \Delta lcf_{t-5}$$

$$+ b_{16} \Delta lcf_{t-6} + b_{17} \Delta lcf_{t-7} - \rho_2 z_{2,t-1} + \upsilon_{1,t-1}$$

$$\Delta lhf_t = c_0 + \sum_{i=1}^{5} c_i D_i + c_6 \Delta plh_{t-1} + c_7 \Delta plh_{t-2} + c_8 \Delta plh_{t-3} + c_9 \Delta plh_{t-4}$$

$$+ c_{10} \Delta plh_{t-5} + c_{11} \Delta plh_{t-6} + c_{12} \Delta lhf_{t-2} + c_{13} \Delta lhf_{t-3} + c_{14} \Delta lhf_{t-4} + c_{15} \Delta lhf_{t-5}$$

$$+ c_{16} \Delta lhf_{t-6} + c_{17} \Delta lhf_{t-7} - \rho_3 z_{3,t-1} + \upsilon_{2,t-1}$$

$$\Delta cf_{t-1} = d_0 + \sum_{i=1}^{5} d_i D_i + d_6 \Delta pc_{t-1} + d_7 \Delta pc_{t-2} + d_8 \Delta pc_{t-3} + d_9 \Delta pc_{t-4} + d_{10} \Delta pc_{t-5}$$
$$+ d_{11} \Delta pc_{t-6} + d_{12} \Delta cf_{t-2} + d_{13} \Delta cf_{t-3} + d_{14} \Delta cf_{t-4} + d_{15} \Delta cf_{t-5}$$

$$+ d_{16} \Delta cf_{t-6} + d_{17} \Delta cf_{t-7} - \rho_4 z_{4,t-1} + \upsilon_{2,t-1}$$

$$\Delta smf_{t-1} = e_0 + \sum_{i=1}^{5} e_i D_i + e_6 \Delta psm_{t-1} + e_7 \Delta psm_{t-2} + e_8 \Delta psm_{t-3} + e_9 \Delta psm_{t-4}$$

$$+ e_{10} \Delta psm_{t-5} + e_{11} \Delta psm_{t-6} + e_{12} \Delta smf_{t-2} + e_{13} \Delta smf_{t-3} + e_{14} \Delta smf_{t-4}$$

[1] Wholesale turkey prices are the simple average of prices in the east for young tom turkeys (14-22 pounds) and of prices in the east for young hen turkeys (8-16 pounds).

$$+e_{15}\Delta smf_{t-5}+e_{16}\Delta smf_{t-6}+e_{17}\Delta smf_{t-7}-\rho_5 z_{5,t-1}+\upsilon_{2,t-1}$$

$$\Delta plc_t = f_0 + f_1\Delta lcf_{t-1} + f_2\Delta plc_{t-1} + \rho_6 z_{2,t-1} + v_{1,t}$$

$$\Delta plh_t = g_0 + g_1\Delta lhf_{t-1} + g_2\Delta lhf_{t-7} + g_3\Delta plh_{t-6} + g_4\Delta plh_{t-7} + g_5\Delta plh_{t-8}$$

$$+\rho_7 z_{3,t-1} + v_{2,t}$$

(35) $$\Delta pc_t = h_0 + h_1\Delta cf_{t-1} + h_2\Delta pc_{t-6} + \rho_8 z_{4,t-1} + v_{3,t}$$

$$\Delta psm_t = k_0 + k_1\Delta smf_{t-1} + k_2\Delta smf_{t-2} + k_3\Delta psm_{t-3} + \rho_9 z_{5,t-1} + v_{4,t}$$

$$bp_t = m_0 + \sum_{i=1}^{5} m_i D_i + m_6 pb_t^e + m_7 fc_{t-1} + m_8 fc_{t-2} + m_9 ha_{t-1} + m_{10} bp_{t-1}$$

$$+m_{11}bp_{t-2} + m_{12}bp_{t-3} + m_{13}bp_{t-4} + m_{14}bp_{t-5} + m_{15}bp_{t-6} + m_{16}bp_{t-7}$$

$$+m_{17}bp_{t-8} + \kappa_t,$$

where: *pb* is the 12-city wholesale price of broilers[2]; *bp* young chicken, total pounds of ready to cook production; *ha* is broiler type chicks hatched in commercial hatcheries, 1000 head; *fc* is broiler grower feed price paid by farmers; *plc* is the cash price of live cattle, Nebraska Direct slaughter steer prices, Choice 2-4, 1100-1300 lbs.[3]; *lcf* is the live cattle futures price; *plh* is the cash price of live hogs, Barrows and Gilts 5/6/7-market average; *lhf* is the live hog futures price; *pc* is the cash price of corn, Chicago number two yellow; *cf* is the corn futures price; *psm* is the cash price of soybean meal, Decatur 44% and 48% protein; *smf* is the soybean meal futures price, $D_i$ are seasonal dummies and $z_i$ are error correction terms.

## Estimation Results

The ten equations (28)-(37), along with the variance-covariance matrix in (26), are estimated jointly as a dynamic system. Full information maximum likelihood estimates (FIML) of the system are obtained by maximizing the unconcentrated log likelihood function. Parameter estimates for the system of equations are presented in Table 1.

Estimates of (28), the quasi-rational forecasting regression, show that the cash price of soybean meal lagged one period has a positive and highly significant impact on wholesale broiler

[2] 9-city wholesale prices, for the period 1966-1977, were adjusted to reflect 12-city wholesale prices.
[3] Omaha slaughter steer prices, Choice 2-4, 1100-1300 lbs., for the period 1966-1970 were adjusted to reflect Nebraska Direct prices.

price changes. Higher feed prices in the two-month period prior to sale translate into higher wholesale broiler prices. The change in the price of broilers lagged one period also has a significant but negative effect on current broiler price changes. Lagged production variables, in the form of the number of chicks hatched in commercial hatcheries, also have a significant effect on wholesale broiler price changes.

Regarding the broiler supply equation (37), the parameter $m_6$ in Table 1 represents the supply elasticity, and indicates the supply response with respect to agents' *ex ante* expectations of the wholesale broiler price. As reported in Table 1, the coefficient $m_6$ is both positive and highly significant, with a value of 0.076 and an associated asymptotic T-ratio of 4.184. This estimate of the short-run supply elasticity is plausible and consistent with prior estimates. For example, Holt and Aradhyula (1998) obtained short-run supply elasticity estimates of around 0.094. Seasonality is also found to be important in modeling broiler supply. Feed costs lagged one and two periods are highly significant and have expected signs. The coefficient on hatch lagged one period is also highly significant and of the expected sign. Eighth order lags on production are also significant, indicating substantial dynamic adjustments in broiler production in the intermediate run.

Recall that expression (27) can be estimated numerically to obtain statistically optimal *ex ante* price expectations. Point estimates along with asymptotic standard errors of the parameters $\tilde{\varpi}$, $\tilde{\gamma}$, $\tilde{\phi}$ and $\tilde{\delta}$, which are the weights attributed to the components of $\alpha_{t-1}$, are derived numerically and are reported in Table 2. According to the T-ratios none of the weighting terms are individually statistically significant at conventional significance levels. Given the apparent individual insignificance of each of the components of $\alpha_{t-1}$, Wald tests are used to determine if the components of $\alpha_{t-1}$ are jointly significant. The results of these tests are reported in Table 3. A Wald test of the joint restrictions that all of the weights in expression (27) are equal to zero is performed. The resulting chi-squared statistic, $\chi_{10}$= 29.36 provides strong evidence that in fact the weights of the components of $\alpha_{t-1}$ are jointly significant. This result indicates that it is important to take into account a combination of informational sources when modeling market agents' true price expectations.

A Wald test of the restriction that the weights on the futures price errors are equal to zero cannot be rejected with a chi-squared statistic of $\chi_4$= 2.38. Thus, the hypothesis that information derived from the futures prices of related commodities plays a role in the formation of agents' price expectations within the broiler market is strongly rejected on the basis of these statistical tests. This result is also confirmed from observation of the historical contribution of futures prices to market agents' *ex ante* price expectations. A sub-sample of the historical contributions of each component of expression (27) in annualized percentage change terms for the period 1968-1974, are reported in Table 4. Evidence from the historical contributions reveal that the supply shocks and the *ex post* broiler price shocks have some impact on *ex ante* price expectations at various times throughout the sample period. For example, over the period February to April of 1968, actual broiler prices increased 5.58% in annualized terms. The quasi-rational forecasting regression was predicting a price increase of some 13.5% over the same time period. The supply error term revised downwards this prediction by almost 2% to bring *ex ante* expectations closer in line to the actual price change at around 11.5%. A Wald test, $\chi_4 = 5.18$, of the restrictions that the weights on the forecast error of future spot prices are zero also could not be rejected.

Statistical evidence reveals that the joint contributions of *ex post* broiler prices, reflected in the error term of the quasi-rational broiler forecasting regression, and the supply shock error term, $\kappa_t$, play a significant role in the formation of agents' price expectations. A Wald test, $\chi_2 = 11.92$, strongly rejects at the 1% significance level the joint restrictions that the weights on the forecasting regression error term and the supply error term are equal to zero. Both of these components of $\alpha_{t-1}$ represent *ex post* sources of information. *Ex post* prices, $p_t$, contain statistical information about $\alpha_{t-1}$ that cannot be observed from either the quasi-rational forecasting regression or futures price alone.

A final Wald test is performed to see if futures prices alone might have contributed to agents' price expectations. The weights on all of the components of $\alpha_{t-1}$ with the exception of futures prices are restricted to zero. This is analogous to including futures prices within the quasi-rational forecasting regression. In this case it is assumed that inferences about agents' true price expectations could be obtained directly from these futures prices. As Hamilton, (1992) points out this approach is not statistically optimal as it excludes the other sources of information contained in $\alpha_{t-1}$. The Wald test, $\chi_6 = 21.15$, strongly rejects the restrictions at the 1% significance level, implying that components of $\alpha_{t-1}$ other than futures prices play a significant role in the formation of agents' price expectations.

## Conclusions

Empirical results based on the 'Hamilton type' model of price expectation formation show that futures prices in fact have a negligible impact on agents' *ex ante* price expectations within the U.S. broiler industry. A quasi-rational forecasting regression, which includes lagged prices and production variables of broilers, is able to account for most of the historical price expectations of agents. This suggests that new information contained in the futures prices of related commodities, is to a large extent embodied in the quasi-rational forecasting regression. However, statistical evidence suggests that the various components of the omitted information term $\alpha_{t-1}$, did have a jointly significant effect on agents' expectation formation. Wald test results, reported in Table 3 indicate that the weighting terms in expression (30) are jointly statistically significant. A Wald test rejected the hypothesis that the weights on the *ex post* broiler price shocks and the supply shocks are equal to zero. This result was confirmed by the results reported in Tables 4 which show the historical contributions of each of the components which make up the inferred *ex ante* price expectations. This suggests that supply shocks and *ex post* broiler price shocks seemed to play a small but significant role in influencing agents' price expectations. Thus, overall the results indicate that although the quasi-rational forecasting regression appears to capture most of the information relevant to forming agents' price expectations in the U.S. broiler market, other informational sources do in fact contribute additional relevant information to the formation of agents' *ex ante* expectations. The results illustrate the importance of taking into account various sources of information when modeling price expectations and the appeal of using an extended version of the Hamilton (1992) type model. This unique modeling approach allowed us to identify the relevant informational sources which contributed to broiler agents' price expectations and address the issue of whether or not futures prices of related commodities play any role in the expectation formation process. The modeling approach followed in this paper differs from previous research by taking into account a combination of informational sources as opposed to assuming that such information sources can be modeled in isolation from each other. A typical approach taken in previous research attempting to model price expectations using futures prices, has been to include the futures prices as explanatory variables in a supply response function, where it is assumed the futures prices represent direct proxies for price expectations. This type of modeling approach follows the work of Gardner (1976). However, if such an approach had been adopted in this paper, and futures prices of the related commodities had simply been included as explanatory variables in the quasi-rational forecasting regression, no weight would have been attached to components of the omitted information term $\alpha_{t-1}$. In the context of the Hamilton type modeling approach, this would have given us an *ex ante* inference of agent's price expectations that would have been sub optimal in a statistical sense. The fact that the various components of the omitted information term $\alpha_{t-1}$ were found to be statistically significant in contributing to the statistically optimal inference of agents' price expectations highlights the relevance of the modeling approach followed in this paper. In addition the modeling approach taken in this paper enabled us to obtain an estimate of the short-run supply response within the U.S. broiler industry. The supply response estimate obtained with respect to *ex ante* price expectations was small in magnitude but highly significant.

## Table 1
## Maximum Likelihood Estimates of Ten-Equation Model for Wholesale Broiler Price Expectations, 1966-1995

**Estimates obtained for the restricted variance-covariance matrix $\Omega$.**

**Restrictions: (1) $\underline{q}^{a} = \underline{q}^{\alpha} = \underline{q}$; (2) $\underline{C}_{q} = 0$.**

**$\sigma_a$ and $\sigma_\alpha$ replace $\sigma_a^2$ and $\sigma_\alpha^2$ respectively.**

| Param | Coeff | Std Error | T-Ratio | Param | Coeff | Std Error | T-Ratio |
|---|---|---|---|---|---|---|---|
| $a_1$ | 0.050 | 0.067 | 0.744 | $b_{11}$ | 0.029 | 0.072 | 0.396 |
| $a_2$ | -0.193 | 0.060 | -3.209 | $b_{12}$ | -0.139 | 0.089 | -1.565 |
| $a_3$ | 0.062 | 0.057 | 1.084 | $b_{13}$ | -0.069 | 0.081 | -0.853 |
| $a_4$ | 0.044 | 0.056 | 0.790 | $b_{14}$ | 0.132 | 0.074 | 1.783 |
| $a_5$ | 0.195 | 0.038 | 5.126 | $b_{15}$ | -0.043 | 0.070 | -0.619 |
| $a_6$ | -0.029 | 0.040 | -0.728 | $b_{16}$ | 0.039 | 0.066 | 0.586 |
| $a_7$ | -0.118 | 0.160 | -0.738 | $b_{17}$ | 0.087 | 0.047 | 1.854 |
| $a_8$ | -0.336 | 0.109 | -3.067 | $\rho_2$ | -0.547 | 0.098 | -5.577 |
| $a_9$ | -0.158 | 0.111 | -1.427 | $c_0$ | 4.372 | 1.564 | 2.795 |
| $a_{10}$ | -0.065 | 0.114 | -0.569 | $c_1$ | 4.745 | 2.394 | 1.982 |
| $a_{11}$ | -0.311 | 0.108 | -2.871 | $c_2$ | -8.221 | 2.303 | -3.570 |
| $a_{12}$ | -0.049 | 0.109 | -0.448 | $c_3$ | 3.374 | 2.004 | 1.684 |
| $a_{13}$ | 0.362 | 0.157 | 2.310 | $c_4$ | -7.238 | 2.556 | -2.832 |
| $\rho_1$ | -0.118 | 0.056 | -2.113 | $c_5$ | 16.186 | 2.228 | -7.266 |
| $b_0$ | 1.506 | 0.623 | 2.419 | $c_6$ | 0.858 | 0.089 | 9.642 |
| $b_1$ | -1.545 | 0.881 | -1.754 | $c_7$ | 0.326 | 0.102 | 3.196 |
| $b_2$ | 0.230 | 0.900 | 0.255 | $c_8$ | 0.051 | 0.101 | 0.508 |
| $b_3$ | -1.471 | 0.906 | -1.623 | $c_9$ | 0.092 | 0.097 | 0.947 |
| $b_4$ | -2.730 | 0.931 | -2.934 | $c_{10}$ | 0.226 | 0.098 | 2.308 |
| $b_5$ | -2.365 | 0.883 | -2.678 | $c_{11}$ | 0.313 | 0.077 | 4.053 |
| $b_6$ | 0.306 | 0.103 | 2.976 | $c_{12}$ | -0.473 | 0.098 | -4.841 |
| $b_7$ | -0.208 | 0.094 | -2.217 | $c_{13}$ | -0.191 | 0.098 | -1.944 |
| $b_8$ | 0.023 | 0.085 | 0.276 | $c_{14}$ | -0.059 | 0.096 | -0.617 |
| $b_9$ | -0.227 | 0.080 | -2.847 | $c_{15}$ | -0.293 | 0.091 | -3.232 |
| $b_{10}$ | 0.216 | 0.073 | 2.974 | $c_{16}$ | -0.208 | 0.080 | -2.589 |

## Table 1 (Continued)

| Param | Coeff | Std Error | T-Ratio | Param | Coeff | Std Error | T-Ratio |
|---|---|---|---|---|---|---|---|
| $c_{17}$ | -0.163 | 0.045 | -3.642 | $e_{11}$ | -0.013 | 0.078 | -0.168 |
| $\rho_3$ | -0.170 | 0.087 | -1.951 | $e_{12}$ | -0.245 | 0.099 | -2.479 |
| $d_0$ | 2.917 | 0.660 | 4.419 | $e_{13}$ | -0.085 | 0.095 | -0.894 |
| $d_1$ | -0.904 | 1.039 | -0.871 | $e_{14}$ | -0.118 | 0.094 | -1.261 |
| $d_2$ | -1.506 | 1.090 | -1.382 | $e_{15}$ | -0.056 | 0.087 | -0.653 |
| $d_3$ | -2.192 | 1.072 | -2.044 | $e_{16}$ | -0.042 | 0.080 | -0.525 |
| $d_4$ | -5.174 | 1.104 | -4.687 | $e_{17}$ | -0.037 | 0.032 | -1.165 |
| $d_5$ | -5.670 | 1.041 | -5.446 | $\rho_5$ | -0.290 | 0.090 | -3.212 |
| $d_6$ | 0.847 | 0.109 | 7.742 | $f_0$ | 0.151 | 0.539 | 0.280 |
| $d_7$ | 0.283 | 0.126 | 2.254 | $f_1$ | 1.143 | 0.143 | 8.010 |
| $d_8$ | 0.410 | 0.113 | 3.631 | $f_2$ | -0.130 | 0.093 | -1.392 |
| $d_9$ | 0.174 | 0.115 | 1.510 | $\rho_6$ | -0.794 | 0.117 | -6.777 |
| $d_{10}$ | 0.251 | 0.098 | 2.578 | $g_0$ | -0.865 | 0.624 | -1.386 |
| $d_{11}$ | -0.095 | 0.094 | -1.008 | $g_1$ | 0.593 | 0.101 | 5.898 |
| $d_{12}$ | -0.470 | 0.122 | -3.851 | $g_2$ | -0.146 | 0.062 | -2.365 |
| $d_{13}$ | -0.367 | 0.116 | -3.175 | $g_3$ | 0.122 | 0.057 | 2.129 |
| $d_{14}$ | -0.290 | 0.113 | -2.569 | $g_4$ | 0.048 | 0.069 | 0.698 |
| $d_{15}$ | -0.238 | 0.101 | -2.366 | $g_5$ | -0.086 | 0.049 | -1.758 |
| $d_{16}$ | -0.082 | 0.091 | -0.905 | $\rho_7$ | -0.425 | 0.087 | -4.861 |
| $d_{17}$ | 0.015 | 0.047 | 0.320 | $h_0$ | -0.391 | 0.583 | -0.670 |
| $\rho_4$ | -0.200 | 0.108 | -1.853 | $h_1$ | 0.956 | 0.119 | 8.024 |
| $e_0$ | 1.976 | 0.639 | 3.092 | $h_2$ | 0.198 | 0.055 | 3.624 |
| $e_1$ | -0.945 | 1.048 | -0.902 | $\rho_8$ | -0.640 | 0.124 | -5.140 |
| $e_2$ | -2.170 | 1.058 | -2.051 | $k_0$ | -0.276 | 0.957 | -0.289 |
| $e_3$ | 0.736 | 1.013 | 0.726 | $k_1$ | 0.533 | 0.157 | 3.392 |
| $e_4$ | -1.206 | 1.062 | -1.136 | $k_2$ | -0.067 | 0.061 | -1.100 |
| $e_5$ | -4.838 | 1.016 | -4.760 | $k_3$ | 0.101 | 0.060 | 1.693 |
| $e_6$ | 0.715 | 0.092 | 7.799 | $\rho_9$ | -0.378 | 0.156 | -2.418 |
| $e_7$ | 0.089 | 0.098 | 0.909 | $m_0$ | -1.113 | 0.207 | -5.389 |
| $e_8$ | 0.141 | 0.097 | 1.455 | $m_1$ | 8.263 | 1.055 | 7.831 |

## Table 1 (Continued)

| Param | Coeff | Std Error | T-Ratio | Param | Coeff | Std Error | T-Ratio |
|---|---|---|---|---|---|---|---|
| $e_9$ | 0.019 | 0.094 | 0.201 | $m_{11}$ | 0.140 | 0.066 | 2.122 |
| $e_{10}$ | 0.048 | 0.088 | 0.552 | $m_{12}$ | 0.144 | 0.056 | 2.541 |
| $m_2$ | 9.346 | 1.073 | 8.713 | $m_{13}$ | 0.042 | 0.056 | 0.743 |
| $m_3$ | 8.056 | 1.259 | 6.397 | $m_{14}$ | -0.208 | 0.058 | -3.594 |
| $m_4$ | 4.568 | 1.189 | 3.844 | $m_{15}$ | 0.232 | 0.058 | 4.030 |
| $m_5$ | 3.726 | 1.024 | 3.640 | $m_{16}$ | 0.218 | 0.064 | 3.415 |
| $m_6$ | 0.076 | 0.018 | 4.184 | $m_{17}$ | -0.233 | 0.056 | -4.166 |
| $m_7$ | -0.060 | 0.023 | -2.621 | $\sigma_a$ | 5.832 | 0.215 | 27.119 |
| $m_8$ | 0.064 | 0.021 | 3.041 | $\sigma_\alpha$ | 0.402 | 0.209 | 1.920 |
| $m_9$ | 0.475 | 0.059 | 8.091 | $\sigma_\eta$ | 2.117 | 0.120 | 17.656 |
| $m_{10}$ | 0.279 | 0.066 | 4.201 | | | | |

## Table 2
## Estimated Weights for *Ex Ante* Wholesale Broiler Price Expectations, 1966-1995

| Component | Weight | Standard Error | T-Ratio |
|---|---|---|---|
| $u_t$ | 0.019609 | 0.035 | 0.560 |
| $\upsilon_{1,t-1}$ | -0.004798 | 0.019 | -0.252 |
| $\upsilon_{2,t-1}$ | 0.003986 | 0.014 | 0.278 |
| $\upsilon_{3,t-1}$ | 0.001130 | 0.008 | 0.136 |
| $\upsilon_{4,t-1}$ | -0.000370 | 0.002 | -0.167 |
| $v_{1,t}$ | -0.008246 | 0.021 | -0.399 |
| $v_{2,t}$ | 0.003708 | 0.006 | 0.660 |
| $v_{3,t}$ | -0.004424 | 0.030 | -0.146 |
| $v_{4,t}$ | 0.001725 | 0.010 | 0.170 |
| $\kappa_t$ | 0.098017 | 0.069 | 1.421 |

## Table 3
## Wald Tests on restrictions of the weights

| Test | R = degrees of freedom | $\chi^2_R$ |
|---|---|---|
| All weights=0 | 10 | 29.36<br>(0.001)* |
| All but futures weight=0 | 6 | 21.15<br>(0.002)* |
| Futures weight=0 | 4 | 2.38<br>(0.666) |
| Spot price forecast error=0 | 4 | 5.18<br>(0.269) |
| Q.R forecasting error term=0<br>And<br>Supply shock=0 | 2 | 11.92<br>(0.003)* |

p-values are in parenthesis, and * indicates significant at the 1% level

# Table 4
## Components of Inferred *Ex Ante* Expectations
## Annualized Percentage Changes

| Year | Actual Value ($p_t$) | Q.R.E regression Forecast | Ex Post Prices | Futures Prices | Market Forecast Errors | Supply Errors ($k_t$) | Expected Prices ($\hat{p}_t^e$) |
|---|---|---|---|---|---|---|---|
| 6804 | 5.58 | 13.50 | -0.16 | -0.02 | 0.09 | -1.83 | 11.58 |
| 6806 | 12.90 | 0.56 | 0.24 | -0.10 | -0.01 | -1.25 | -0.56 |
| 6808 | 12.78 | -2.80 | 0.31 | 0.15 | 0.04 | 0.69 | -1.61 |
| 6810 | -50.82 | -31.53 | -0.38 | -0.07 | -0.33 | 0.76 | -31.55 |
| 6812 | -7.50 | -37.50 | 0.59 | -0.12 | -0.54 | -2.47 | -40.04 |
| 6902 | 42.90 | 16.02 | 0.53 | -0.13 | 0.23 | 0.31 | 16.96 |
| 6904 | 15.84 | -2.24 | 0.35 | -0.03 | -0.25 | -1.39 | -3.56 |
| 6906 | 31.50 | 7.40 | 0.47 | 0.07 | -0.39 | 1.72 | 9.27 |
| 6908 | 27.54 | 1.81 | 0.50 | -0.07 | 0.38 | -1.01 | 1.62 |
| 6910 | -52.80 | -48.83 | -0.08 | 0.11 | -0.12 | 0.82 | -48.10 |
| 6912 | -40.32 | -39.05 | -0.02 | 0.15 | 0.35 | -1.03 | -39.62 |
| 7002 | 16.02 | 20.45 | -0.09 | -0.16 | 0.34 | 0.18 | 20.72 |
| 7004 | -17.28 | 22.49 | -0.78 | 0.09 | -0.36 | 0.41 | 21.85 |
| 7006 | -10.26 | 9.80 | -0.39 | 0.01 | -0.10 | -0.41 | 8.92 |
| 7008 | -21.00 | 4.78 | -0.51 | -0.18 | -0.04 | -0.30 | 3.75 |
| 7010 | -2.34 | -5.34 | 0.06 | -0.03 | -0.31 | -0.10 | -5.72 |
| 7012 | -11.82 | 7.99 | -0.39 | -0.13 | 0.19 | -0.07 | 7.59 |
| 7102 | 39.36 | 35.48 | 0.08 | 0.16 | -0.31 | -2.26 | 33.14 |
| 7104 | -1.26 | 10.80 | -0.24 | -0.10 | -0.02 | 0.86 | 11.30 |
| 7106 | 44.40 | 25.07 | 0.38 | 0.04 | -0.10 | -1.81 | 23.57 |
| 7108 | 4.08 | 12.06 | -0.16 | 0.42 | -0.16 | 1.23 | 13.39 |
| 7110 | -54.90 | -58.61 | 0.07 | -0.20 | 0.23 | -0.89 | -59.40 |
| 7112 | -47.64 | -42.89 | -0.09 | 0.07 | -0.22 | 2.89 | -40.24 |
| 7202 | 69.90 | 48.31 | 0.42 | 0.15 | 0.04 | 1.76 | 50.69 |
| 7204 | -14.94 | 17.52 | -0.64 | 0.13 | -0.12 | -0.63 | 16.26 |
| 7206 | 21.00 | 21.24 | 0.00 | 0.03 | -0.16 | 2.93 | 24.04 |
| 7208 | 32.10 | 12.95 | 0.38 | -0.06 | 0.14 | 0.49 | 13.90 |
| 7210 | -5.82 | -20.10 | 0.28 | 0.16 | -0.37 | 0.01 | -20.03 |
| 7212 | -25.62 | -10.14 | -0.30 | -0.16 | 0.52 | 1.31 | -8.77 |
| 7302 | 132.90 | 77.03 | 1.10 | -0.28 | 0.32 | -1.52 | 76.66 |
| 7304 | 113.10 | 63.41 | 0.97 | -0.12 | -0.05 | -2.66 | 61.56 |
| 7306 | -10.02 | -1.14 | -0.17 | -0.28 | -0.48 | 0.23 | -1.84 |
| 7308 | 158.46 | 55.58 | 2.02 | 0.13 | -0.34 | -0.48 | 56.91 |
| 7310 | -125.76 | -46.66 | -1.55 | -0.02 | 1.03 | 0.31 | -46.90 |
| 7312 | -130.56 | -117.17 | -0.26 | 0.07 | 0.19 | 0.54 | -116.63 |

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