Linear Feedback Between European Wheat Export Refunds And World Wheat Prices

By

Ronald L. Roeber*

2002 Annual Meeting of the American Agricultural Economics Association

Copyright 2002 by Ronald L. Roeber. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies

* Ronald Roeber is a professor and coordinator of Information and Educational Technology Services in the Institute of Ag and Natural Resources—University of Nebraska-Lincoln.
Abstract

This paper explores the dynamic relationships between European Union (EU) wheat export restitution awards and price movements in the world wheat market from November 20, 1986 through April 24, 1998. This study pairs the results of weekly EU open market tenders and corresponding foreign wheat export prices in a series of bivariate non-structural. From these models a feedback measure is calculated which estimates the contribution of innovations in wheat prices to the variance in export tenders and vice versa. Feedback was decomposed into patterns—short-term and long-term—that approximate patterns of strategic behavior or political strategy. The study showed overall feedback and short-term innovations in wheat export prices and European restitution awards are relatively small. As the length of the feedback decomposition increases directional feedback diverges. The importance of export price changes to European restitution awards increases in long-run relationships. In contrast weekly EU restitution awards decrease in their importance to wheat export price changes as decomposition periods increase. The general pattern found in the study seem to indicate that world export prices contribute substantially to long-term variations in EU open market tender awards, while these awards appear to have negligible effects on long-term international wheat price determination. Short-run and long-run feedback results provide evidence in support of an international wheat market that is minimally influenced by the administration of EU export subsidies. The long-term conduct of European wheat export policy appears to have been influenced to some degree by the international wheat market.

Introduction

European wheat export subsidies have drawn the attention of the world’s other major exporters. Trade theory and traditional models predict the effect these subsidies should have in a world wheat market. However, the world wheat market exhibits properties that violate many of the assumptions applied in traditional trade models. Of particular interest is the participation of governmental and quasi-governmental institutions that possess market power in the world wheat trade, including the European Commission (Carter et al., 1990). Substantial portions of European export subsidies are administered through an open market tender process rather than as standing refunds. The European Commission’s Cereal Management Committee (CMC) convenes weekly—Christmas and Easter weeks excepted—to determine the quantity of exports to be subsidized and the value of the refunds per metric ton. As they evaluate wheat export tenders the CMC has the opportunity to reflect upon world market conditions and to consider the consequences of their own actions on world prices. Because the EU is a large wheat exporter, the European Commission has the capacity to administer export subsidies in a strategic fashion. Evidence of European strategic behavior in the world wheat market would carry implications for modeling and evaluating the effects of European wheat subsidies.

The purpose of this study is to investigate the effects of EU export refunds awarded through open market tenders in the world wheat market. The period under investigation begins shortly after the initiation of the US Export Enhancement Program (EEP) and ends as major exporters begin compliance with the Uruguay round of WTO agreements (1986-1998). This study will examine
European wheat export subsidies in the context of a dynamic relationship between policy implementation and international wheat prices. Feedback between prices and EU exports are decomposed into long-term and short-term relationships. A better understanding of a dynamic relationship between EU export subsidies and international wheat prices would benefit the development of several models and interpretations of international wheat.

**Background**

Policy modeling exercises involving commodities such as wheat usually work with the assumption that international agricultural markets are perfectly competitive, observation and evidence would suggest otherwise. Governmental and quasi-governmental institutions invested with marketing power by large wheat exporting nations are awkward realities (Carter et al., 1990; McCalla et al., 1981; and Ackerman and Dixit, 1999). Trade models based on imperfect competition are less comfortable vehicles for policy analysis since small differences in behavioral assumptions can produce varying and conflicting policy prescriptions (Sarris, 1981 and McCalla & Josling, 1981). Furthermore, the behavior and practices of large state trading enterprises (STE) are often shrouded in secrecy, offering little in the way of data that could be used to analyze their behavior (Ackerman and Dixit, 1999).

In models of the international wheat market, European export restitutions are usually represented as a wedge between the world price and domestic European target price. This representation is drawn directly from theoretical and observational properties of the European agricultural policy. Under the CAP, wheat and other grains are subject to a variable levy system that “automatically” adjusts border prices in response to world price movements. The levy provides trade researchers two important ingredients for wheat export models. First, since the levy system is designed and implemented to isolate domestic European wheat market from the vagaries of world price movements, price transmission from the international market into the European economy is assumed to be zero. Secondly, the price differential (wedge) maintained by the levy system offers a convenient representation for European export subsidies.

European variable levies were implemented when the EU was a net wheat-importing region, so the variable levy for wheat functions as a variable tariff. Granted, now that the EU exports wheat into the world market the price differential supported by the levy must be closely linked to European subsidies. However the levy is not technically a subsidy. European wheat export subsidies are awarded through a bidding process that allows the European Commission’s Cereal Management Committee
(EC-CMC) to manage export price and quantity of exports over the course of time. The active role of the EC-CMC in overseeing wheat exports has been the subject of few research efforts (Becker, 1991; Burgeon and Le Roux, 1996a; Burgeon and Le Roux, 1996b). If the EC-CMC awards restitutions in response to—or anticipation of—world price changes, or if they account for the effects of their own actions in the international market, European export subsidies may not qualify as an exogenous variable in trade models.

The weekly pattern of choices by the Cereals Management Committee may contain revealing information about the administration of EU wheat subsidies and the world's major wheat exporters. Weekly export tender results are a rare short-period, time-series policy instrument providing an opportunity to explore the relationship between its implementation and the behavior of world wheat prices.

**Approach**

Measurement of linear dependence between economic variables provides an estimation of the relative predictive importance between these sets of variables over time. The non-structural VAR approach used in this study employs feedback measurements developed by Geweke (1982) and McGarvey (1985). These methods are comparatively unconstrained allowing for complex interactions such as those that are likely to exist between wheat export prices and European export policy. In contrast to non-causality tests proposed by Granger (1969) and Sims (1980) feedback analysis does not test point hypotheses. Rather, bias adjusted feedback is measured between two variables—export price and European export restitutions. The comparison of these linear feedback measures and the corresponding proportion of prediction error explained may reveal patterns in the international wheat market. Evidence of patterned feedback may be useful for building and refining more structured models of the international wheat market and the role that European export subsidies play in world wheat price determination.

The study addresses three main questions. 1) Is there evidence of a dynamic relationship between the administration of EU wheat export restitutions and wheat export prices of other exporting countries? 2) Do EU wheat export subsidies function as exogenous shocks to international wheat markets or does the administration of restitutions through open market tenders convey evidence of strategic trade? 3) Should feedback relationships exist, are they consistent with recognizable patterns of industrial and/or political adjustment?
Using methods developed by McGarvey (1985), feedback relationships between variables can be decomposed into frequency bands that correspond to familiar seasonal, industrial and political rhythms. Directional feedback is decomposed by time intervals to test for short, medium and long run relationships between export prices and EU wheat export refunds. Time intervals chosen *a priori* for examination in this study are short-term (less-than-one-month and one-to-five-months), production response (6 to 18 months), political (1.5 to 5 years) and long-term (beyond five years). During the short-term period, governments and firms (including wheat producers) would be very limited in their capacity to adapt or respond to the effects of weekly EU subsidies. The length of the production season period would correspond to planting decisions by producers and allow government agencies to respond within the context of policy available to them. The political period roughly contains the length of the US Farm Bill, the period between EU CAP adjustments and elections cycles in many of the developed countries. Long-term effects would include “permanent” adjustments in the dynamic relationship between wheat export prices and EU wheat export restitutions.

Feedback responses derived from these price/policy regressions are not dependent upon market structure. Peculiarities such as wheat class and quality variations, large exporting countries and governmental agencies invested with market power should not detract from the results of this study. Price/policy relationships can be studied independently of the actual market structure of the wheat trade. Market imperfections may also result from political economy interactions and national strategic trading policies (McCalla et al., 1981; Carter et al. 1990). The dynamic role of policy implementation in wheat price formation—European open market tenders in particular—has not received much attention.

**Empirical Analysis**

**Data**

The data sets used for this analysis include weekly wheat price data of four major international exporters and published European weekly wheat export restitutions awarded through open market tenders encompassing the period November 20, 1986 through April 24, 1998. The price series are constructed from two sources. Through June of 1991, price series are taken from a report prepared for the Wheat Export Trade Education Committee (Goodwin and Smith, 1995). The remainder of the price series was obtained from the International Grains Council’s Grain Market Report of London. All prices are f.o.b. in $US per metric ton. Wheat prices include Trigo pan (Argentina),
Australian Standard White and #1 Canadian Western Red 13.5% wheat. US wheat prices are for hard red wheat, Gulf.

The data series for European export restitutions was gathered from weekly issues *Agra-Europe*. The publication reports the results of the regular meetings of the European Commission’s Cereals Management Committee including information on open market tenders for wheat export restitutions. The data series representing the volume of the export subsidy is metric tons of common wheat made eligible weekly through successful tenders to the EC-CMC.

**Table 1: Stationarity tests for weekly data series.**

<table>
<thead>
<tr>
<th>Weekly Data Series</th>
<th>Augmented Dickey Fuller (µ) - 50 lags Critical level, 5% Values; -3.12 &amp; 0.23</th>
<th>KPSS η(µ) Critical level, 5% Critical value, ≥ .463 (Lags 0 - 4: which are parameters in the covariance estimator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN #1 Canadian Western Red 13.5% wheat US$/MT</td>
<td>-3.16011 5.12805 4.09399 2.74641 2.07287 1.66926</td>
<td></td>
</tr>
<tr>
<td>EXRV Volume of export tenders awarded by the EC-CMC. MT</td>
<td>-2.72529 0.24891 0.21254 0.18125 0.16456 0.15116</td>
<td></td>
</tr>
</tbody>
</table>

The lag period used for the regressions in this study was determined by weighing the tradeoffs between optimal and ideal values. Optimal lag length was estimated using Akaike and Schwarz test
in RATS (Estima, 1995). Pairing European policy instruments with wheat export prices, the optimal lag length was found to fall within the range of 18 to 22 weeks for all planned regressions. There is also the matter of an ideal lag length that must be considered comparing results between different time periods when decomposing variance by frequency. Geweke (1982) notes that when feedback values for different time periods \( f_{x \rightarrow p}(\lambda_0) \) and \( f_{x \rightarrow p}(\lambda_1) \) are both of interest, the optimal lag length should be at least \( 2\pi/|\lambda_0 - \lambda_1| \). Under these circumstances, the collection of weekly data series is well suited to comparisons over periods of a few weeks, but to determine differences over longer periods of time—which are also of interest—the ideal lag period would be in excess of 100.

This set of data series is long enough to support 100+ lags, however the results of the Akaike and Schwarz tests would tend to indicate that longer lags may prove to be so variable as to preclude their usefulness. The regressions used in this study were run for lag periods of 25, 50, 75, and 100. After 50 lags, confidence intervals for feedback measures became excessively high while the differences between 25 and 50 lags were very small. To strike a balance between the optimal and ideal lag length, a value of 50 was chosen.

Each price and export series was tested for stationarity using the augmented Dickey Fuller test and the KPSS test. All of the export price series and the series for export subsidy value exhibit evidence of non-stationarity. The subsidy volume series for open market tenders produce conflicting test results (Table 1). The null hypothesis for the DF unit root test is that there is a unit root. The null hypothesis for the KPSS test is that there is not a unit root. Since the KPSS test statistic strongly suggests that the weekly volume of open market tenders is a stationary series, the variable EXRV will be treated as a stationary series, paired with the differenced export prices from each of the four export price series.

**Measuring Linear Feedback**

The degree of linear dependence between wheat export price changes \((p)\) and European export restitution awards \((x)\) is measured using methodology developed by Geweke (1982). Linear dependence in a bivariate system is defined in terms of the following projections, where \( p \) and \( x \) are linearly indeterministic stationary processes.
\[ p_t = \sum_{s=1}^{\infty} a_1(s) p_{t-s} + \sum_{s=1}^{\infty} a_2(s) x_{t-s} + \epsilon_{it} \quad (1) \]

\[ p_t = \sum_{s=1}^{\infty} b_1(s) p_{t-s} + \sum_{s=0}^{\infty} b_2(s) x_{t-s} + \epsilon_{it} \quad (2) \]

\[ p_t = \sum_{s=1}^{\infty} c_s(s) p_{t-s} + \epsilon_{it} \quad (3) \]

Unconditional feedback between \( x \) and \( p \) is derived from the error terms in equations (1) through (3) as follows:

\[
F_{x \to p} = \log \left( \frac{\text{Var}(\epsilon_x)}{\text{Var}(\epsilon_p)} \right)
\]

\[
F_{p \to x} = \log \left( \frac{\text{Var}(\epsilon_p)}{\text{Var}(\epsilon_x)} \right)
\]

\[
F_{x \cdot p} = \log \left( \frac{\text{Var}(\epsilon_x)}{\text{Var}(\epsilon_p)} \right) = F_{p \cdot x}
\]

The first ratio (\( F_{x \to p} \)) is the directional feedback from \( x \) to \( p \). Feedback from \( p \) to \( x \) (\( F_{p \to x} \)) can be calculated by switching \( x \) and \( p \) in equations (1) and (3). The measure \( F_{x \to p} \) is zero if and only if \( x \) fails to Granger cause \( p \) (this would be equivalent to the condition \( a_z(s) = 0 \) for all \( s \)).

Total linear dependence between \( x \) and \( p \), \( F_{x,p} \), is defined as follows,

\[
F_{x,p} = F_{x \to p} + F_{p \to x} + F_{x \cdot p}
\]

where \( F_{x \cdot p} \) is the measure of contemporaneous feedback between \( x \) and \( p \).

Each feedback measure is transformed by calculating, \( 1 - \exp(-F) \). The transformation is the reduction in one-step-ahead linear prediction error variance of \( p \) due to \( x \), given past \( p \) (or \( x \) due to \( p \), given past \( x \), when the variables are switched in equations (1) and (3)).
McGarvey (1985) extends Geweke’s method of measuring feedback to the moving average form of the system. Like Geweke’s measure, McGarvey’s can be decomposed by frequency allowing interactions to have both short and long term effects. For the purpose of illustrating McGarvey (1985) feedback the vector $z_t = (p_t, x_t)'$ is used to maintain consistency of notation. Let $z_t$ be a $2 \times 1$ vector of jointly wide-sense stationary, linearly indeterministic processes with the following autoregressive representation:

$$
B(L)z_t = \left( I - \sum_{s=1}^{\infty} B(s)L^s \right)z_t = w_t \quad (4)
$$

where $w_t$ is serially uncorrelated with mean zero and a covariance matrix $\Omega$.

The series $z_t$ must be transformed in such a way that the concurrent errors are uncorrelated so that the effects of orthogonal innovations can be attributed to only one element of $z_t$. A Choleski transformation is used to restrict the contemporaneous coefficient matrix on $z_t$ to be lower triangular with ones on the diagonal.

The moving average (MA) representation of (4) is obtained by inverting the transformed VAR system. The MA representation of $z_t = (p_t, x_t)'$ in terms of the orthogonalized innovations $\eta_t = (e_t, u_t)'$ is as follows,

$$
z_t = G(L)\eta_t \quad (5)
$$

where $B(L) = G(0)G(L)^{-1}$ and $w_t = G(0)\eta_t$.

Overall feedback from export restitution shocks, $u$, to wheat export price changes is defined as follows

$$
F_{u \rightarrow p} = \ln \left( \frac{\text{Var}(p)}{\text{Var}(p) - \sum_{s=0}^{\infty} g_{12}(s)^2 \text{Var}(\eta_2)} \right) \quad (6)
$$
As with Geweke feedback the transformation \(1 - \exp(-F_{u,p})\) represents that proportion of \(p\)’s variance due to shocks from \(x\). In a bivariate system, McGarvey and Geweke feedback measures are equivalent.

McGarvey and Geweke feedback can be decomposed by frequency, separating longer-run effects from those that may be more transient. The European Commission’s Cereals Management Committee (EU-CMC) weekly export tender decisions may affect—or be affected by—short-term export price movements. Perhaps the administration of export subsidies tracks or leads pricing patterns that may be periods of several months or even years. Higher feedback measure would be expected in the higher frequency bands if export restitution awards were tied primarily to short-term adjustment in wheat export prices. The overall feedback measure can also be used to test lower frequency bands representing longer-term interaction.

The spectral density of \(p\) in the bivariate system can be written as:

\[
S_p(\lambda) = \tilde{G}_{11}(\lambda)^2\sigma^2 + \tilde{G}_{12}(\lambda)\sigma_u^2
\]  

(7)

with the \(\text{Var}(p) = (1/2\pi)\int_{-\pi}^{\pi} S_p(\lambda) d\lambda\) over all \(\lambda\) from \(-\pi\) to \(\pi\).

Using the spectral density matrix \(S_p(\lambda)\), overall frequency feedback results can be decomposed by frequency interval \((\lambda_1, \lambda_2)\) as follows:

\[
f_{u-p}(\lambda_1, \lambda_2) = \ln\left(\frac{\int_{\lambda_1}^{\lambda_2} S_p(\lambda) d\lambda}{\int_{\lambda_1}^{\lambda_2} (S_p(\lambda) - \tilde{G}_{12}(\lambda)\sigma_u^2) d\lambda}\right) \]  

(8)

The transformation of the feedback result \(\left(1 - f_{u-p}(\lambda_1, \lambda_2)\right)\) would represent the fraction of \(p\)’s variance related to cycles of periods \(2\pi/\lambda_2\) to \(2\pi/\lambda_1\) (weeks) as a result of innovations in \(x\).

To illustrate, suppose \(z_{t,p}\) represents weekly wheat export price changes \((p)\) and \(z_{t,x}\) is the weekly volume of wheat export restitutions \((x)\) awarded by the EC-CMC. Let the frequency band \((\lambda_1, \lambda_2)\) be equivalent to four-week periods. Equation (9) would then represent the proportion
of the variance in export price changes \( z_{i,t} (p) \) due to cycles of one-month periods that is due to innovations in export restitution awards \( z_{j,t} (x) \).

**Regressions and Tests**

Using the software program RATS (Estima, 1995) the following autoregressive system was estimated by OLS.

\[
z_{i} = -\sum_{s=1}^{50} B(s)z_{i-s} + w_{i},
\]

where \( z_{i} = (p_{i}, x_{i})' \) and \( w = (w_{1}, w_{2}, ...)' \) where \( E(w, w') = \Omega \). Now construct \( \hat{B}(L) \) as follows,

\[
\hat{B}(L) = \text{I} + \sum \hat{B}(s)L^s.
\]

Let \( K \) be an upper triangular matrix such that \( KK' = \Omega^{-1} \). Using \( \hat{B}(L) \) and \( K \) the following orthogonalized system was used to construct the feedback estimators.

\[
K\hat{B}(L)z_{i} = K\hat{w}_{i} = \eta_{i}, \text{ where } E\left[ \sum_{t=1}^{T} \eta_{i}^{'}\eta_{i}^{''}/T \right] = \text{I}.
\]

At each of 520 frequencies, a Fourier transformation of \( \hat{B}(L) \) was evaluated to construct \( \hat{B}(\lambda) \) \((\lambda = 0, \pi/260, ... , 2\pi)\). The inverse of this matrix was calculated at each frequency producing the estimator of the cross-spectral density matrix of \( z \), \( \hat{S}(\lambda) = \hat{G}(\lambda)\hat{G}(\lambda)' \), where \( \hat{G}(\lambda) = \hat{B}(\lambda)^{-1} K^{-1} \).

The linear feedback estimator of European export restitutions \( (x) \) to wheat export price \( (p) \) over frequency band \( \theta = [\lambda_1, \lambda_2] \) is calculated as follows

\[
\hat{f}_{u \rightarrow p} (\theta) = \ln \left( \frac{\sum_{\lambda=\lambda_1}^{\lambda_2} \hat{S}_p (\lambda)}{\sum_{\lambda=\lambda_1}^{\lambda_2} \left( \hat{S}_p (\lambda) - \hat{G}_{12} (\lambda)^2 \right)} \right).
\]
where $\hat{S}_{p}(\lambda)$ and $\hat{G}_{21}(\lambda)$ are the (1, 1) and (1, 2) elements of the 2 x 2 matrices $\hat{S}(\lambda)$ and $\hat{G}(\lambda)$. Total feedback from $x$ to $p$ is estimated by using $\theta = [0, 2\pi]$. Conversely feedback from $p$ to $x$ would be estimated from the same set regressions and transformations using the following test statistic

$$\hat{f}_{p\rightarrow x}(\theta) = \ln\left(\frac{\sum_{\lambda=\lambda_{h}}^{\lambda_{l}} \hat{S}_{p}(\lambda)}{\sum_{\lambda=\lambda_{h}}^{\lambda_{l}} (\hat{S}_{p}(\lambda) - \hat{G}_{21}(\lambda)^2)^{1/2}}\right).$$

For this statistic $\hat{S}_{p}(\lambda)$ would be the (2, 2) element of $\hat{S}(\lambda)$ and $\hat{G}_{21}(\lambda)$ would be the (2, 1) element of $\hat{G}(\lambda)$. These test statistics were estimated for each national wheat export price in combination with the weekly volume of wheat export restitutions approved for export by the EC-CMC.

In addition to total feedback estimations, test statistics were calculated for time periods that may reflect economic or political patterned responses. The periods chosen include innovations that occurred within less than a month $\theta = [33\pi/130, 2\pi]$, within one to five months $\theta = [11\pi/130, 131\pi/260]$, from six to eighteen months $\theta = [3\pi/130, 21\pi/260]$, two to five years $\theta = [\pi/130, 5\pi/260]$ and infinite feedback $\theta = [0, 0]$. Notice how the “width” of the frequency bands representing longer time periods becomes narrower as the time period of interest gets longer. So much so that many long term effects may overlap and be difficult to separate, especially with only 50 lags in the autoregressive model. As mentioned earlier, the trade-off with more lag periods would inflate the variability of the estimates that would make confidence intervals for the feedback measures very large for all frequency bands.

**Bias Correction and Confidence Intervals**

Bias corrections and confidence interval estimation are based on methods described by Cushing and McGarvey(1990). For the unconditional estimators of the feedback measures, the 50-lag autoregressive model used to estimate the test statistic was run using each country’s export wheat price paired with open market export tender data. The beta coefficients and variance results for the
population estimates from each autoregression were calculated over the weekly data series encompassing 20-November-1986 through 24-April-1998 \((T = 578)\).

Using Monte Carlo techniques in RATS (Estima, 1995), 200 sets of simulated data were constructed using the first 50 actual observations in weekly data series and estimated values using the estimated parameters from the test regressions for the remaining variables represented by

\[
\hat{\mathbf{B}}(L)\mathbf{z}_t = \mathbf{e}_t \text{ where } \mathbf{e}_t \sim N(0, \hat{\Omega}).
\]

Each set of the 200 simulations generated an expected value for the feedback estimator for the model\(E(f)\), a value for the tenth centile \((L)\) and the ninetieth centile \((U)\). Note that \(P(L < f < U) = 0.8\) serves as the basis for a confidence interval surrounding the population feedback measure.

Now let \(F\) be the population feedback measure and define the following variables: \(\ell = L/E(f)\), \(u = U/E(f)\) and, \(a = F/E(f)\),

\[
P(\ell E(f) < f < uE(f)) = 0.8 \text{ or } P(aE(f) < af < auE(f)) = 0.8
\]

where \(af\) is an unbiased, or bias adjusted estimator of \(F\).

From the Monte Carlo experiments the parameters \(a^i\), \(\ell^i\) and \(u^i\) were calculated by averaging each of the values for \(L/E(f)\), \(U/E(f)\) and \(F/E(f)\), from the \(k\) different autoregressive pairings between price and exports. For each type of feedback measure, the estimated 80% confidence interval published with the bias adjusted feedback measure is

\[
f_o(a^i/u^i) < F < f_o(a^i/\ell^i)
\]

where \(f_o\) is the feedback point estimate for a particular pairing of price and exports.

The 80% Confidence interval using the estimated values \(a_o^i = F/\bar{f}\), \(\ell_o^i = L/\bar{f}\) and \(u_o^i = U/\bar{f}\) can be written
\[ f_o \left( \frac{a_o^i}{u_o^i} \right) > F > f_o \left( \frac{a_o^i}{\ell_o^i} \right). \]

This procedure ensures that the bias adjusted estimated feedback \( \left( a_o^i, f_o \right) \) falls within the estimated confidence interval. The number of sampling distributions estimated for each autoregressive pair of data in this study include: Geweke contemporaneous, \( k = 1 \); Geweke directional \( k = 2 \); Geweke linear dependence, \( k = 1 \); and McGarvey frequency decompositions and overall feedback, \( k = 6 \).

**Results**

**Overall Feedback**

The first column of numbers in **Table 2** represents the directional feedback measure between variables. The right-most column includes the transformation \( 1 - \exp \left( F_{x \rightarrow y} \right) \), the corresponding proportional reduction in predictive error variance between volume of wheat export refunds and changes in export wheat prices.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Adjusted Estimate</th>
<th>Proportion of Prediction Error Variance Explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_{USA \rightarrow EXRV} )</td>
<td>.0467</td>
<td>.0456 (.0203, .0868)</td>
</tr>
<tr>
<td>( F_{EXRV \rightarrow USA} )</td>
<td>.0285</td>
<td>.0281 (.0124, .0540)</td>
</tr>
<tr>
<td>( F_{USA \cdot EXRV} )</td>
<td>.0017</td>
<td>.0017 (.0008, .0033)</td>
</tr>
<tr>
<td>( F_{USA, EXRV} )</td>
<td>.0764</td>
<td>.0736 (.0339, .1338)</td>
</tr>
<tr>
<td>( F_{ARG \rightarrow EXRV} )</td>
<td>.0323</td>
<td>.0318 (.0140, .0608)</td>
</tr>
<tr>
<td>( F_{EXRV \rightarrow ARG} )</td>
<td>.0309</td>
<td>.0305 (.0135, .0584)</td>
</tr>
<tr>
<td>( F_{ARG \cdot EXRV} )</td>
<td>.0027</td>
<td>.0027 (.0012, .0052)</td>
</tr>
<tr>
<td>( F_{ARG, EXRV} )</td>
<td>.0654</td>
<td>.0633 (.0291, .1157)</td>
</tr>
<tr>
<td>( F_{AUS \rightarrow EXRV} )</td>
<td>.0341</td>
<td>.0336 (.0148, .0642)</td>
</tr>
<tr>
<td>( F_{EXRV \rightarrow AUS} )</td>
<td>.0511</td>
<td>.0498 (.0221, .0945)</td>
</tr>
<tr>
<td>( F_{AUS \cdot EXRV} )</td>
<td>.0030</td>
<td>.0030 (.0013, .0057)</td>
</tr>
<tr>
<td>( F_{AUS, EXRV} )</td>
<td>.0875</td>
<td>.0838 (.0387, .1517)</td>
</tr>
<tr>
<td>( F_{CAN \rightarrow EXRV} )</td>
<td>.0416</td>
<td>.0407 (.0180, .0776)</td>
</tr>
<tr>
<td>( F_{EXRV \rightarrow CAN} )</td>
<td>.0316</td>
<td>.0311 (.0137, .0595)</td>
</tr>
<tr>
<td>( F_{CAN \cdot EXRV} )</td>
<td>.0005</td>
<td>.0005 (.0002, .0010)</td>
</tr>
<tr>
<td>( F_{CAN, EXRV} )</td>
<td>.0731</td>
<td>.0705 (.0324, .1283)</td>
</tr>
</tbody>
</table>

*Table 2. Geweke Measure of Linear Dependence Between Weekly Wheat Export Price Changes and the Volume of European*
Over the 11½-year period the linear dependence between export price changes and European open market tender awards are similar for all four countries. For example, slightly more than seven percent \((1 - \exp(F_{EXRV \rightarrow USA}) = .0736)\) of the variance in US wheat export prices and the volume EU tender awards can be attributed to innovations in the other series. The connection between EU tender awards and wheat export price changes in the other three regions was correspondingly similar: Argentina 6.3 percent; Canada 7.0 percent; and Australia 8.4 percent. Confidence intervals suggest world wheat export prices and EU open market tender awards account for as little as 3 percent (US) or as much as 15 percent (Australia) of the total predicted error variance between wheat export prices and the EU subsidy.

For all four major wheat exporters, the magnitude of the total feedback relationship is similar for the respective directional feedback estimates. The largest divergence is found in the relationship between US and Australian wheat export price movements and EU tender awards where the proportion of predictive variance from prices to restitution awards differs by only 1.7 percentage points (US: .0456 - .0281 = .0174, AUS: .0511-.0341=.170). The 80 percent confidence intervals for predictive variance reduction do not draw a distinction between overall direction of feedback either from prices to subsidies or from subsidies to prices. What can confidently be said of the price-export feedback relationship is that contemporaneous variation between tender awards and each of export price series is negligible and clearly less than predictive variance from any of the directional feedback interactions. The contemporaneous feedback between EU restitution awards and wheat export price changes are near or under 0.3 percent in each country \((F_{USA \times EXRV} = .0017)\). The contemporaneous relationship between Canadian wheat prices and EU restitution awards is smaller than for corresponding interactions in Australian and Argentina with 80 percent confidence; however, with all values less than one percent this appears to be an unimportant result.

The absence of a contemporaneous relationship is consistent with the conduct of the open market tender process or any policy instrument for that matter. It is difficult to imagine a scenario in which EU-CMC tender award decisions could vary simultaneously with movements in world wheat prices. Economic explanations could account for explanatory variance originating from either of these series. European tender awards could lead price changes if the subsidy approvals elicited
shocks in world wheat prices. Conversely, international wheat price movements could factor into EU-CMC tender award decisions and a corresponding variance reduction would be expected from the opposite direction. Although several times larger than contemporaneous feedback directional results are not at all large

Consider possible influences on international wheat prices over a span of 11½ years including, but not limited to, the effects of weather, global economic performance and political interventions. One could argue that the six to eight percent reduction of prediction error variance between past weekly wheat export price movements and past EU weekly wheat subsidy awards indicates the relationship between EU subsidies and international wheat prices is an important one. The smaller, individual directional feedback estimate from export prices to restitution awards and those from the awards back to prices are more problematic, explaining less than 5 percent of the predictive error variance from either variable to the other. The smaller numbers could more easily be dismissed as unimportant if there were no a priori reason to suspect feedback between these variables. International tensions surrounding European wheat export restitutions and the importance of the weekly process for awarding them support the a priori suspicions that there is some feedback. Based on these observations and the results in Table 2, there is slight evidence of feedback over time between wheat export prices and EU open market, but the magnitude of the overall feedback was relatively small compared to other factors involved in wheat export price formation.

Geweke overall feedback estimates in both directions were very similar for each set of export prices. The absence of a distinction between the relationship involving changes in different countries’ wheat export prices and EU restitution awards is not unexpected. The long period encompassed by the study and the tendency of international wheat prices to move together over time make it difficult to isolate country specific effects of EU restitution awards.

Feedback Decomposition

Geweke and McGarvey total feedback measures are equivalent in bivariate autoregressive systems. Overall feedback relationships as estimated by the McGarvey method can be decomposed into long-term and short-term patterns. For example, the EU uses export prices of the US and Argentina as a guideline for setting standing restitutions. A short-term feedback relationship may exist between these price series and EU open market tender awards that might be masked in the
long run. From the other direction, exporters that sell wheat most closely matching European exports in class and quality could experience greater short-run shocks to prices as a result of EU tender awards. The results of McGarvey feedback and decomposition of variance by time period are listed in Tables 3a and 3b. For each of the four exporting regions, two directional feedback estimates are listed for each time period. Column-wise transversals of the result in Table 3 provide a country-by-country look at the predictive variance relationships between wheat export prices and European open market tender awards for each time period. A row-wise transversal to the results in Table 3 (treating 3a & 3b as a single table) offer a time-period by time-period look at the relationships between each exporting nation and EU restitution awards.

<table>
<thead>
<tr>
<th>Export Country Period</th>
<th>Proportion of Prediction Error Variance Explained (80% Confidence Interval) by Innovations Between European Export Open Market Restitution Volume and Export Wheat Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>United States</td>
</tr>
<tr>
<td></td>
<td>USA→EXRV→USA</td>
</tr>
<tr>
<td>Overall</td>
<td>.0528 (.0241, .0969)</td>
</tr>
<tr>
<td>Infinite</td>
<td>.2171 (.1044, .3686)</td>
</tr>
<tr>
<td>2 to 5 years</td>
<td>.1849 (.0880, .3190)</td>
</tr>
<tr>
<td>6 to 18 months</td>
<td>.0554 (.0253, .1016)</td>
</tr>
<tr>
<td>1 to 5 months</td>
<td>.0552 (.0252, .1012)</td>
</tr>
<tr>
<td>&lt; 1 month</td>
<td>.0475 (.0217, .0874)</td>
</tr>
</tbody>
</table>


The overall reduction in the proportion of predictive variance calculated using McGarvey feedback is equivalent to the overall feedback estimated using Geweke feedback. The similarities between overall predictive variance estimation in Tables 2 and 3 demonstrate this relationship. Since McGarvey and Geweke overall feedback are theoretically equivalent, differences in the estimated values between procedures can be attributed to precision during the calculation process. The calculation of McGarvey feedback requires several data transformations including numerous matrix operations, real-to-imaginary series conversions and Fourier transformation of the beta
coefficients. The two feedback methods yield very similar results. The only point estimates that draw attention are for Argentina where Geweke estimations of predictive variance explained are very close to the same for feedback in each direction, (\(\text{ARG} \to \text{EXRV} = .0323\) and \(\text{EXRV} \to \text{ARG} = .0309\)) while the McGarvey counterparts differ slightly more (\(\text{ARG} \to \text{EXRV} = .0412\) and \(\text{EXRV} \to \text{ARG} = .0274\)). Even so, 80 percent confidence intervals show that a distinction cannot be made between these overall values for either McGarvey or Geweke feedback.

<table>
<thead>
<tr>
<th>Export Country</th>
<th>Australia</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>(\text{AUS} \to \text{EXRV})</td>
<td>(\text{EXRV} \to \text{AUS})</td>
</tr>
<tr>
<td>Overall</td>
<td>.0384</td>
<td>.0405</td>
</tr>
<tr>
<td>Infinite</td>
<td>.2617</td>
<td>.0078</td>
</tr>
<tr>
<td>2 to 5 years</td>
<td>(.1277, .4345)</td>
<td>(.0035, .0147)</td>
</tr>
<tr>
<td>6 to 18 months</td>
<td>.0873, .3169</td>
<td>.0058, .0238</td>
</tr>
<tr>
<td>1 to 5 months</td>
<td>.0456</td>
<td>.0481</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>.0354</td>
<td>.0368</td>
</tr>
</tbody>
</table>
| Overall variance is decomposed into five different time periods. Time-period specific values for proportional predictive variance in Table 3 are that portion of the overall relationship that varies in a pattern that matches the time period length. Feedback for these decompositions can exceed overall feedback. Shocks that vary in their persistence (frequencies) or coincide with shocks that originate from the opposite direction of the feedback relationship can dampen or hide each other. Infinite feedback is that proportion of variance attributable to past innovations in the companion variable where the time pattern is infinite in length—permanent effects. The two-to-five-year feedback period is a pattern that approximates the periodic responses of political or industrial changes. The European CAP and US Farm Bill revision would fit under this pattern, as would election cycles and moderately long-term adjustment in the wheat industry. The six-to-eighteen-month period is of a

<table>
<thead>
<tr>
<th>Export Country</th>
<th>Australia</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>(\text{AUS} \to \text{EXRV})</td>
<td>(\text{EXRV} \to \text{AUS})</td>
</tr>
<tr>
<td>Overall</td>
<td>.0384</td>
<td>.0405</td>
</tr>
<tr>
<td>Infinite</td>
<td>.2617</td>
<td>.0078</td>
</tr>
<tr>
<td>2 to 5 years</td>
<td>(.1277, .4345)</td>
<td>(.0035, .0147)</td>
</tr>
<tr>
<td>6 to 18 months</td>
<td>.0873, .3169</td>
<td>.0058, .0238</td>
</tr>
<tr>
<td>1 to 5 months</td>
<td>.0456</td>
<td>.0481</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>.0354</td>
<td>.0368</td>
</tr>
</tbody>
</table>

length that could include seasonal adjustment in planting or storage by wheat producers. Six-to-eighteen-months would also include short-term government policy responses. One-to-five-months is a less immediate response to price movements or restitution awards. One important relationship that fits within this period is the requirement that European export firms use EU open market tender awards within six months. The shortest period listed is less-than-one-month in length. Short period feedback would include very immediate responses between the variance of wheat export price movements and EU restitution awards.

The feedback decompositions of the relationship between US wheat export price changes and EU open market tender awards indicate that there are directional feedback differences. The magnitude of feedback is proportionally much greater in the direction of US export prices to open market tender awards than it is for the European restitutions to US wheat export price changes. The proportion of predictive variance explained is higher during each time period from prices to subsidies. The difference appears more so for the longer time periods than for the short-run segments. Nearly 22 percent of the variance corresponding to permanent effects in the volume of EU open market tender could be attributed to innovations in US wheat export prices. Conversely, just under two percent of the variance in US wheat export prices could be credited to the volume of European wheat export restitutions awarded through open market tenders. A very similar and seemingly one-sided association between price and subsidy is also evident for the political-industrial pattern of 2 to 5 years. In the three decompositions representing time periods of less than 2 years, predicted error variance proportions were less than 6 percent with estimates being higher from US export prices to EU restitutions. Eighty-percent confidence intervals indicate that infinite feedback from US price to EU restitution volume is more important than for any other portion of the decomposed variance in either direction. For the other US price to export decompositions, feedback patterns approximating two-to-five-year patterns cannot be considered different from the six-to-eighteen-month and one-to-five-month patterns. However, two-to-five-year shocks appear to produce greater effects than feedback patterns of less-than-one-month. The confidence intervals fail to distinguish between any of the feedback effects for different time periods in the direction of EU open market tender awards to US wheat export prices. According to these results, the administration of European subsidies accounts for a relatively small proportion of the weekly variance in US wheat export prices.
Wheat export price feedback patterns for the remaining three countries generally follow the same pattern as that exhibited by US export price changes. The similarities extend to both the magnitude and direction of the feedback decompositions. For Argentina, the largest feedback relationships between wheat export price changes and EU restitution awards was in the direction of prices to subsidies over the long term. For shocks with permanent effects, variations in Argentine wheat export prices accounted for 14 percent of the predicted error variance in EU restitution awards. The same directional feedback accounted for nearly 17 percent of the variance in two-to-five-year patterns. The point estimates of directional feedback from Argentine prices were lower at other frequencies, however 80 percent confidence intervals indicate that the two-to-five-year feedback from Argentine prices to EU subsidies is greater than one-to-five-month and less than one-month patterns. Infinite feedback from Argentine price changes to EU subsidies is greater than the less-than-one-month relationship. Six-to-eighteen-month patterns of feedback are indistinguishable from the other decompositions.

Administration of the European open market tenders is proportionally much less important to Argentine export price movements. Predictive error variance in Argentina wheat export prices explained by EU restitution awards is less than three percent for each of the time period decompositions. The feedback relationships from Argentine price to EU subsidy are indistinguishable from each other based on the 80 percent confidence interval estimates. For the two shortest periods the feedback relationship is similar in each direction. Between three and four percent, the short-term feedback relationship between Argentine prices and EU restitution awards closely resembles the overall feedback estimates.

The analysis of Australian wheat export prices and EU export restitutions produced some of the most distinct results between time periods. For infinite shocks, innovations in Australian wheat export prices account for approximately a quarter (.2617) of the predicted variance explained for EU restitutions in the bivariate system. Confidence intervals indicate that infinite feedback from Australian prices to EU restitutions is larger than feedback decompositions for all of the other time periods in either direction. The two-to-five-year pattern (.1836) is larger than all other decompositions with two exceptions: one-to-five-months and six-to-eighteen-month patterns in the direction of EU restitutions to Australian wheat prices. As was also the case with Argentina,
feedback estimates involving Australian wheat for infinite and two-to-five-year decompositions are much larger in the direction of price to EU restitutions.

Not only are long term feedback estimates for EU restitutions to Australian wheat export prices smaller than feedback in the opposite direction for comparable time periods; infinite feedback from EU wheat subsidies to Australian export prices is smaller than feedback in the same direction than the three shortest periods. Similarly, feedback from subsidies to prices for periods of two-to-five-years is smaller than the one-to-five-month decomposition. Predicted variance reduction for Australian wheat export prices due to innovations in EU restitutions was 5 percent or slightly less for the decomposition of variance in patterns of 6-18 months, 1-5 months and less-than-one-month. At 80 percent confidence, the shortest three periods of decomposition were indistinguishable from each other in either of the directional feedback estimates involving EU restitutions and Australian wheat export prices.

The Canadian wheat export price relationship with European wheat export restitutions closely mimics that of the Australia’s. The proportion of variance in European restitutions accounted for by innovations in Canadian wheat prices is larger for infinite and two-to-five-year decompositions than for six-to-eighteen-month and one-to-five-month periods (.1638 and .1456 vs. .0339 and .0343). The variance reduction in Canadian wheat prices attributed to shocks in EU restitutions could be considered negligible for both the infinite (.0007) and one to five year (.0024) decompositions. The preponderance of directional feedback in periods greater than two years seems clearly to be greater from Canadian prices to EU restitutions than from restitutions to prices. Even though the proportion of variance reduction in Canadian wheat export prices due to innovations in EU wheat subsidies is relatively small for variance decompositions less than two years in length (~2.5-3.5 percent), the infinite and one-to-five-year patterns are even smaller than these modest levels.

Country-by-country analysis indicates that EU restitutions have a relatively small effect on wheat export prices of major wheat exporting nations. The modest effect seems even less important to long run export price changes. World wheat prices tend to have a greater impact on the volume of EU restitutions awarded through the weekly open market tender system.
Now considered row-by-row comparing the different regional export prices by time period (rows spanning Tables 3a and 3b). Feedback from EU wheat export restitutions to wheat export prices is far less than feedback in the direction of prices to subsidies. Point estimates for infinite effects of the proportional variance explained in EU restitutions by export price changes range from 14 percent (Argentina) to 26 percent (Australia). Export price to subsidy feedback is equivalent for all countries according to 80 percent confidence bands. The permanent effects of EU restitution awards on export price changes are only one tenth that of the corresponding feedback from price changes to subsidies. The proportional reduction in Canadian price changes due to variance in EU export subsidies was very near zero (.07 percent) and is less than that measured for US (1.7 percent), Argentina (1.5 percent) and Australia (0.8 percent). EU restitution awards do not seem to have had permanent effects on wheat export prices. International wheat price movements do appear to have contributed substantially to long-term patterns of EU open market tender awards.

The two-to-five-year period roughly approximating political cycles and industry adjustments shows very nearly the same pattern and magnitude of feedback found for permanent effects. The 80 percent confidence intervals for export prices to EU restitutions are all very nearly the same with estimates of variance reduction ranging from 14.5 percent (Canada) to 18.5 percent (United States). Feedback from EU wheat subsidies to wheat export prices is again on the order of one-tenth that of the countervailing feedback. At less than 2 percent--except for Canadian price feedback which is even less than that of other export prices—EU export restitutions have accounted for little of the variance in wheat export price changes in two-to-five-year patterns. In contrast, major exporter wheat prices have accounted for a considerable amount of the variation in EU export tender awards in the two-to-five-year pattern.

For the six-to-eighteen-month period, fewer differences are found in the magnitude of feedback in either direction. Although larger variance reductions can generally be attributed to feedback from wheat export price to EU restitutions (USA excepted: 4.5 percent vs. 4.8 percent) the measures are mostly indistinguishable from one another based on 80 percent confidence intervals. One difference between two countries does occur in feedback from EU subsidies to export price. Within 80 percent confidence, the feedback from EU wheat export subsidies to Australian export prices is greater than the feedback for the EU restitutions to Argentina export prices. It can also be said that the feedback from any of the major exporters’ wheat prices to EU restitutions is larger than feedback from EU
restitutions to Argentine export price. Canadian and US feedback, based on the confidence intervals
cannot be distinguished from either Argentina or Australian price feedback measured in the
direction of subsidy to price. As the time period in question shortens and grows closer to the time of
the EU weekly tender award, the magnitude of the effect of price begins to diminish. As for
feedback of EU subsidies to price, it is difficult to say in general, but feedback may be increasing
slightly for Canada and Australia. This cannot be said with certainty. Class and quality of Argentine
and Australian wheat are more similar to EU wheat exports than Canadian or US wheat exports
used in this study. It seems odd that they would exhibit different magnitudes of response to EU
export restitutions. The differences could be due more to political and economic policies than wheat
type.

Now consider the 80 percent confidence intervals for the bivariate feedback measurements that
match the patterns of less-than-one-month and one-to-five-months respectively. All point estimates
of feedback in both directions for these two periods are under six percent but greater than two
percent. Distinctions between any of these estimates cannot be made using the 80 percent
confidence intervals. The short-term interrelationship between European export restitutions and
world export prices seems to be on the order of importance as overall feedback relationships. The
proportional variance reductions in the one-to-five-month and less-than-one-month frequency bands
seem to indicate that recent world export prices have little if any role in determining the volume and
timing of EU open market tender awards. By the same token, since EU open market tender awards
must be executed in less than six months, it would appear that the timing of export subsidies from
the European Union have a small immediate effect on world export prices.

Conclusion
. Overall feedback between export prices and the volume of European Union subsidy awards
appears to be a relatively small factor in the formation of international wheat prices. When
decomposed by time period some differences begin to emerge. Short-term innovations in wheat
export prices and European restitution awards are relatively small. As the length of the feedback
decomposition increases directional feedback diverges. The importance of export price changes to
European restitution awards increases in long-run relationships. In contrast weekly EU restitution
awards decrease in their importance to wheat export price changes as decomposition periods
increase in length. Differences in feedback due to country of origin are few and possibly could be
attributed to unique features of export policy or similarity to European exports. These findings are less remarkable than the general conclusion that world export prices contribute substantially to long-term variations in EU open market tender awards, while these awards appear to have negligible effects on long-term international wheat price determination.

By using time-series policy variables, this study provides supporting evidence that European wheat export subsidies for wheat can be considered an exogenous variable for the purposes of modeling the international wheat market. Though the European Commission would appear on the surface to be able to manage the timing and volume of exports to its advantage, in the international marketplace there is no evidence that such strategy is employed. Short-run and long-run feedback results provide evidence in support of an international wheat market that is minimally influenced by the administration of EU export subsidies. European wheat export policy appears to have been influenced to some degree by the international wheat market. Economic theory tells us that export subsidies by large exporting countries distort the market. The results from this study do not contradict theory. Rather, the study indicates that from Europe’s example even though government policies distort markets, the implementation of the policy does not allow them to manipulate international wheat markets to their advantage.

References


