Institutional Impact of GATT:
An Examination of Market Integration and Efficiency in the World Beef and Wheat Market under the GATT Regime

Jacinto F. Fabiosa

Working Paper 99-WP 218
April 1999

Center for Agricultural and Rural Development
Iowa State University
Ames, IA 50011-1070

Jacinto F. Fabiosa is an assistant scientist with the Food and Agricultural Policy Research Institute (FAPRI), Center for Agricultural and Rural Development (CARD), Iowa State University.

For questions or comments about the contents of this paper, please contact Jacinto F. Fabiosa, Center for Agricultural and rural Development, Iowa State University, 579 Heady Hall, Ames, IA 50011-1070; phone: 515-294-6183; fax: 515-294-6336; e-mail: jfabios@gcard.iastate.edu.

Contents

Abstract ... 5
Introduction ... 7
Model ... 10
Empirical Implementation and Results ... 13
Summary and Conclusion ... 16
Tables ... 18
Figures ... 22
Acronyms and Abbreviations ... 25
References ... 27

Tables

Table 1. Percentage comparison of estimated ad-valorem tariff equivalent, 1986-99 and tariffs declared in country schedules 18

Table 2. GATT tariff quota 18

Table 3. GATT maximum allowable subsidized export 19

Table 4. Share of exports and imports to countries in the same market segment 19

Table 5. Augmented Dickey-Fuller test 20

Table 6. Johansen Cointegration test 20

Table 7. Long-run relationship and speed of adjustment 21

Table 8. Variance decomposition for the beef market 21

Table 9. Variance decomposition for the wheat market 22

Figures

Figure 1. Proportion of countries and final bound rate for beef in GATT 22

Figure 2. Share of Australian beef price innovation in the variance of U.S. beef price 23

Figure 3. Share of U.S. beef price innovation in the variance of Australian beef price 23

Figure 4. Share of Australian wheat price innovation in the variance of U.s. wheat price 24

Figure 5. Share of U.S. wheat price innovation in the variance of Australian wheat price 24

Abstract

Studies on the General Agreement on Tariffs and Trade (GATT) are abundant in the literature. But most researchers have examined GATT's impact on economic activities with scant or no attention given to its impact on institutions such as market integration and efficiency. To the latter issues, this paper is addressed.

Even prior to the signing of the final act, questions were raised on possible maneuvers that might frustrate its intent, that of ushering in an era of true liberalization in agricultural trade. This study finds consistent evidence that GATT reforms promoted market integration and improved market efficiency.

Decomposition of price variability into its various sources shows that the transmission of shocks becomes more widespread across markets and is much faster under the GATT regime. This, in turn, suggests improved market integration. The share of unexpected shocks originating from other prices in the variability of U.S. beef prices increased under GATT from 15 to 30 percent, 14 to 46 percent for Australian beef prices, 20 to 43 percent for U.S. wheat prices, and 19 to 54 percent for Australian wheat prices. Also, cointegration analysis shows significant improvement in market efficiency particularly in the speed at which a market adjusts to departures from its long-run equilibrium. Within the Pacific beef market the speed of adjustment increased under GATT from 0.309 to 0.609; between the Pacific beef and the Atlantic beef market the speed of adjustment increased from 0.246 to 0.592; and the wheat market speed of adjustment increased from 0.064 to 0.414.

Key Words: market integration, market efficiency, cointegration, vector autoregression, GATT, beef and wheat markets.

Introduction

The historic Uruguay Round Agreement on Agriculture (URAA) accomplished what has eluded the GATT for a long time, that of putting agricultural trade under the same umbrella as that of other sectors (e.g., manufacturing). In particular, it aimed to dismantle trade-distorting policies through the introduction of disciplines that included ensuring and expanding market access, and limiting domestic support and export subsidy.

Even prior to the signing of the Final ACT, questions were raised concerning the wide latitude in the rules of implementation stipulated in the URAA. These rules are open to maneuvers that might frustrate the intent of ushering in an era of true liberalization in agricultural trade. The six-year implementation period is about to close, and with the revisitation just a year away, the GATT compliance record so far is mixed at best. For example, although tariffication agreements converted all non-tariff barriers (NTBs) into tariff equivalents that were to be cut by 24 to 36 percent, and Minimum Access Volume (MAV) insured access at a minimum of 3 to 5 percent of base consumption, “dirty tariffication” limited the reduction in effective protection. Table 1, reproduced from Ingco (1995), shows that for several countries the URAA ad-valorem rate for 1995 in wheat and beef are even higher than the estimated ad-valorem rate for the base period 1986-98. Although Aggregate Measure of Support (AMS) declined by 40 percent, which is much higher than the 13 to 20 percent required in the URAA, support under the “green-box” policies (not subject to reduction commitments under GATT) increased by 54 percent. Although countries made an export subsidy reduction commitment of 14 to 21 percent, strong prices in 1995 and 1996 made them redundant. With all these shortcomings, did GATT make any difference in agricultural trade at all?

Studies on the impact of GATT are abundant in the literature. However, they have mostly focused on the impact of GATT on economic activities such as production, consumption, trade, and prices, using either a general equilibrium model such as GTAPP or partial equilibrium agricultural trade models of the Food and Agricultural Policy Research Institute (FAPRI), U.S. Department of Agriculture (USDA), Organization of Economic Cooperation and Development (OECD), and the Australian Bureau of Agricultural Resource Economics (ABARE). For example, Veeman (1994), Brester and Wohlgennant (1997), Marsh (1997), and Fuller and Hayes (1998) examined the impact of GATT on price levels of traded agricultural commodities. Fausti and Qasmi (1998) examined changes in trade patterns with GATT, while Borges (1995), Song and Carter (1996), and Gunter, Jeong, and White (1996) examined the welfare implications of GATT. However, very scant attention has been given on the impact of GATT in improving the functioning of institutions such as the world agricultural commodity markets. The reforms introduced by GATT are institutional in nature (i.e., changes on "rules of the game"). The impact on economic activities in some sense is secondary since the institutional change aspect of GATT precedes them.

This study examines whether GATT reforms improved market integration and efficiency, using the beef and wheat markets as specific cases. Market integration is defined similar to McNew and Fackler (1997), that is, in terms of the degree that shocks arising in one market price are passed on to other market prices. On the other hand, the concept of market efficiency is more narrowly defined in terms of the speed at which market prices adjust to departures from their equilibrium relationship.

The world beef market is used as a specific case because the pre-GATT regime of beef trade that was subject to reforms under the URAA, had been highly protected by measures that impeded market integration and efficiency. In particular, access to beef markets was expanded and ensured through tariff rate quotas (TRQ). That is, for countries with significant beef imports, current access commitments required them to grant market access opportunities on terms and at levels no less than the average quantities imported during the base period (1986 to 1988). For countries with minimal beef imports, minimum access opportunities set the level of market access at 3 percent of average consumption in the base period, and to grow to 5 percent throughout the implementation period.

Imports within the TRQs are charged a low or minimal in-quota rate that is not to exceed 32 percent of their bound tariff commitments. Table 2 shows that the total initial TRQ in beef is 1.161 million metric tons (mmt) and grows to 1.301 mmt at the end of the implementation period. This market access represents 23.93 percent of the 1994 world beef trade. The TRQ in beef exceeded that of pork, which was at 10.67 percent, both in terms of the level of the TRQ and the TRQ expressed as a proportion of total trade. Moreover, the URAA commitments reduce the maximum amount of allowable subsidized beef exports from 1.513 mmt to 1.129

mmt, representing 31.20 percent of trade (see table 3). In terms of its proportion to world trade, the allowable subsidized export in beef is smaller than that of pork, which is at 38.18 percent.

Figure 1 shows the final bound rate in beef for selected countries. Sixteen percent of countries had a final bound rate of less than 15 percent, 42 percent had a final bound rate of 15 to 50 percent, 21 percent had a final bound rate of 50 to 100 percent, and 21 percent had a final bound rate of more than 100 percent. The wheat market is used to examine whether the same pattern of institutional impact in meat can be observed for crops. Wheat is a highly traded commodity with world trade representing 20 percent of world wheat production. Moreover, similar to beef, the pre-GATT period wheat trade was subject to substantial distortion, with subsidized wheat exports representing 47 percent of total trade. The URAA reduces the maximum allowable subsidized wheat export by 31 percent at the end of the implementation period.

The URAA disciplines radically changed domestic and trade policies of several countries that are significant players in the world beef market. The European Union (EU), the fourth largest beef importer after the United States, Japan, and Russia, and the third largest beef exporter after Australia and the United States, ended its variable levy in beef. The EU allowed a TRQ of 161 thousand metric tons (tmt) at an in-quota rate of 20 percent and limited its export subsidy to 822 until 2000. The United States replaced its quota under the Meat Import Law with a TRQ of 656.621 tmt. Japan abolished the beef import quota in a 1990 agreement and replaced its base rate of 93 percent with a bound rate of 50 percent, in 1995. This is set to further decline to 38.5 in the year 2000. Mexico, the sixth largest importer, has liberalized its imports of fresh/chilled/frozen beef since January 1994 according to the North American Free Trade Agreement (NAFTA). Full liberalization of beef variety meats will follow by 2003. Although South Korea, the seventh largest importer, is fully liberalizing only its beef imports by 2001, the share of the more market-oriented Simultaneous Buy-Sell (SBS) system is increasing—expected to capture 70 percent of South Korea's 206 tmt import quota this year.

Another feature of the world beef market that impeded market efficiency is its segmentation into the Pacific and Atlantic beef markets, where the latter represents beef trade among countries where foot-and-mouth disease (FMD) is endemic. While countries with FMD are able to import from countries without FMD, they could not export frozen, fresh, and chilled beef products to FMD-free countries.

Australia and the United States are major players in the Pacific market, while Argentina and the EU are the major players in the Atlantic market. Table 4 shows that the imports of countries in the Pacific beef market are solely sourced from within that market, while imports of some countries in the Atlantic beef market are partially sourced from outside. Except for Argentina, exports of the Atlantic beef market are to countries within that market. Argentina (and maybe Brazil) export processed beef to the Pacific beef market. Australia and New Zealand export to countries in the Atlantic market.

The major change in the wheat market was the limit imposed on subsidized EU wheat exports. From the high EU wheat export of 20 mmt in the early 1990s (with a large portion subsidized), it had to operate within the maximum allowable subsidized wheat export of 16.8 mmt in 1998/98.

Model

This methodology of study departs from earlier studies on the GATT. Whereas earlier studies had to specify some general or partial equilibrium structure, this study employs time series methods with minimum structural specifications and allows the associative behavior (i.e., correlation structure) of the data to "speak-for-itself."

Several studies have used the concept of cointegration to test for market integration: Goodwin (1992), Goodwin and Grennes (1994), Benson et al. (1994), and Silvapulle and Jayasuriya (1994). McNew and Fackler (1997), however, questioned the appropriateness of the use of the presence and number of linear long-run relationship of a cointegrating vector as an indicator of market integration. This study uses innovation accounting to directly measure market integration. This method allows direct measurement of price variability and its decomposition to the various sources of variability from the variability of all other prices in the system. The test for market efficiency is based on the speed of adjustment and the elasticity implied in the cointegrating vector.

Dynamic price behavior of a given market can be represented by [1]

[1] $$Y_t = \sum_{i=0}^{N} Y_{t-i} B_i + \mu_t ,$$

where Y_t is a vector of endogenous prices; N is the lag length; B_i is a conformable coefficient matrix; and μ_t is a vector of primitive exogenous disturbances with distribution $\mu \sim N[0, \Sigma]$. To avoid identification problems, the Vector Auto Regression (VAR) model is used as a reduced form of [1], i.e.,

[2] $$Y_t = \sum_{j=1}^{N} Y_{t-i} C_i + \upsilon_t ,$$

where $C_i = B_i (I - B_0)^{-1}$, and $\upsilon_t = (I - B_0)^{-1} \mu_t$.

There are three possible reformulations of the VAR model in [2] to adequately handle the particular stationarity property of a given price vector Y_t. To choose the appropriate model, consider a reparameterized version equivalent to [2], i.e.,

[3] $$\Delta Y_t = \sum_{j=1}^{N-1} \Gamma_j \Delta Y_{t-j} - \Psi Y_{t-1} + \upsilon_t ,$$

where $\Gamma_i = f(C_i)$ and $\Psi = (I - C_1 - C_2 - . . . - C_N)$.

If the rank of $\Psi$is full, then using levels in [2] presents no statistical problem. On the other hand, if the rank of Ψ is zero then a different version of [2] is adequate. However, if the rank of Ψ is $0 < r < N$ then the ECM in [3] is the appropriate model. The dynamic relationship of prices is fully captured by the three terms of the RHS of [3]. Moreover, the specification lends easily to disaggregating the impact of fundamentals on the level of prices and impact of unexpected shocks on price variability. The impact of fundamentals on the level of prices is captured in the long-run relationship represented by ΨY_{t-1}. The parameter ψ can be expressed as $\Psi = \alpha\beta'$, where β' is the cointegrating vector such that $\beta' Y_{t-1}$ (i.e., equilibrium error) is stationary, and α measures the speed of adjustment from past equilibrium errors.

On the other hand, the impact of unexpected shocks on the variability of prices is captured by the innovation vector υ_t. Consider a VMAR representation of the VAR, i.e.,

[4] $$Y_t = F(L) \nu_t ,$$

where L is a lag operator, $F(L) = [I - C(L)L]^{-1}G$ and $\nu_t = G^{-1}\upsilon_t$. G is the Choleski decomposition of Σ. An i^th equation of [4] is

$$[5] \qquad y_{it} = \sum_{j=0}^{T\to\infty} f_{i1}(j)\nu_{1,t-j} + \ldots + \sum_{j=0}^{T} f_{ii}(j)\nu_{i,t-j} + \ldots + \sum_{j=0}^{T} f_{in}(j)\nu_{n,t-j}.$$

The total variability of the price vector can now be decomposed into its various sources. The unconditional variance of y_{it} can be easily derived from (5), i.e.,

$$[6] \qquad Var(y_{it}) = \tau_i^2 = \sum_{j=0}^{T\to\infty} f_{i1}(j)^2\sigma_1^2 + \ldots + \sum_{j=0}^{T} f_{ii}(j)^2\sigma_i^2 + \ldots + \sum_{j=0}^{T} f_{in}(j)^2\sigma_n^2,$$

where σ_i^2 is the variance of the innovation of the i^{th} variable. Let $P_r(Y \mid I(T-r))$ be the optimum r-step-ahead predictor of Y given all information up to T-r. Based on equation [5], the forecast for the i^{th} good is

$$[7] \qquad P_r(y_i \mid I(T-r)) = \sum_{j=r}^{T\to\infty} f_{i1}(j)\nu_{1,t-j} + \ldots + \sum_{j=r}^{T} f_{ii}(j)\nu_{i,t-j} + \ldots + \sum_{j=r}^{T} f_{in}(j)\nu_{n,t-j}.$$

Then the forecast error is the difference between (5) and (7), i.e.,

$$[8] \qquad FEy_{ir} = \sum_{j=0}^{r-1} f_{i1}(j)\nu_{1,t-j} + \ldots + \sum_{j=0}^{r-1} f_{ii}(j)\nu_{i,t-j} + \ldots + \sum_{j=0}^{r-1} f_{in}(j)\nu_{n,t-j}.$$

The forecast error is really a truncated version of VMAR itself. It is for this reason that the variability of y_{it} can also be examined in terms of the forecast error variance, which is equal to

$$[9] \qquad Var(FEy_{ir}) = \pi_{ir}^2 = \sum_{j=0}^{r-1} f_{i1}(j)^2\sigma_1^2 + \ldots + \sum_{j=0}^{r-1} f_{ii}(j)^2\sigma_i^2 + \ldots + \sum_{j=0}^{r-1} f_{in}(j)^2\sigma_n^2.$$

This expression is standardized in [10] to facilitate interpretation and comparison.

$$[10] \qquad 1 = \sum_{j=0}^{r-1} f_{i1}(j)^2\frac{\sigma_1^2}{\pi_{ir}^2} + \ldots + \sum_{j=0}^{r-1} f_{ii}(j)^2\frac{\sigma_i^2}{\pi_{ir}^2} + \ldots + \sum_{j=0}^{r-1} f_{in}(j)^2\frac{\sigma_n^2}{\pi_{ir}^2},$$

Each RHS term captures the proportion of the variability of y_i due to the respective variability of the variables in the vector.

In a VAR model, all variables are treated as endogenous. If this is true, the data should be able to indicate their endogeneity. That is, a variable whose variability is explained largely by other variables (i.e., $\sum_{p \notin i}^{n} \sum_{j=0}^{r-1} f_{ii}(j)^2 \frac{\sigma_p^2}{\pi_{ir}^2}$ is large) is a likely candidate to be classified as endogenous. As a corollary, a variable that explains a large proportion of its own variability is a likely candidate to be classified as an exogenous variable. That is, the sum $\sum_{j=0}^{r-1} f_{ii}(j)^2 \frac{\sigma_i^2}{\pi_{ir}^2}$ must be large.

Empirical Implementation and Results

Data used in this study are monthly beef and wheat prices from the International Financial Statistics covering the period June 1986 to April 1998. Beef prices are for frozen beef in U.S. dollars per pound. The U.S. beef price is FOB New York, while Australia and Argentina beef price are cost of insurance and freight (CIF) in U.S. East Coast ports. Wheat prices are in U.S. dollars per bushel. The U.S. wheat price is hard red winter wheat, FOB Gulf of Mexico ports, while Australia wheat price is Wheat Board export price. All estimation was done using Regression Analysis of Time Series (RATS) for Windows version 4.3.

The price variables were first tested for nonstationarity to select the most appropriate representation of the model. The Augmented Dickey-Fuller Test (ADF) is used for this purpose. Each price series is assumed to have a data generating process that is adequately described by a univariate version of model [3] with varying assumptions about the intercept and trend. Table 5 shows that the all the price series for beef and wheat are nonstationary. That is, since in many of the cases the absolute values of the test statistics are lower than the critical values at 10 percent significant level, we cannot reject the null hypothesis of nonstationarity. This means that the individual price series can wander away with no tendency to revert to their mean. However, there may be an equilibrium relationship that governs their comovements over time such that departures from this equilibrium condition are temporary. This might occur because economic forces at play provide an internal tendency for these variables to revert to their equilibrium level.

The existence of an equilibrium relationship of beef prices and wheat prices was first examined by testing for the presence of a linear combination of the prices that are stationary using the Johansen Maximal Eigenvalue and Trace of Stochastic Matrix method. The Pacific beef market price equilibrium was tested for the U.S. and Australian beef price. Table 6 shows that the Johansen test suggests two cointegrating vectors between the Australian and U.S. beef price in the pre-GATT period and one cointegrating vector in the post-GATT period. The Pacific-Atlantic beef market price equilibrium was tested for the Australian and Argentinean beef price. The Johansen test suggests one cointegrating vector between the Australian and Argentinean beef price in the pre-GATT period and two cointegrating vectors in the post-GATT period. The same result is shown for the long-run relationship of the Australian and U.S. wheat prices. Since the result on the number of cointegrating vectors is mixed for the pre-GATT and post-GATT period, the study proceeded by imposing only one cointegrating vector in all cases.

Very strong evidence was found that GATT disciplines promoted market efficiency in both the world beef and wheat markets, despite reported maneuvers that frustrated the true intent of the URAA. Table 7 shows that within the Pacific market, the fundamental relationship of Australia and U.S. beef price significantly improved with the long-run transmission elasticity implied in the cointegrating vector increasing from 0.243 in the pre-GATT period to 0.289 in the post-GATT period. More importantly, however, is the significant improvement in the speed of adjustment, which increased from 0.309 to 0.609, respectively. That is, whenever the U.S. and Australia beef prices depart from their long-run equilibrium relationship, the Pacific beef market becomes more efficient under the GATT regime in the sense that the speed of adjustments back toward an equilibrium have doubled under the post-GATT regime. Also, this speed of adjustment parameter is very significant with a t-ratio of 4. Even the fundamental relationship of beef prices between the segmented Pacific and Atlantic markets improved significantly.

In the pre-GATT period, the trade policy distortions and segmentation of the market may have corrupted the price transmission between the two markets at -0.065. GATT reforms corrected this inverse relationship with a price transmission elasticity of 0.07, and increased the speed of adjustment by 2.4 times from 0.246 to 0.592. The lower transmission elasticity under GATT within the Pacific-Atlantic beef market compared to within the Pacific market may be explained by the continuing segmentation of the two markets. This trend may have been strengthened under the GATT agreement on sanitary and phytosanitary measures. However, the increasing across-market beef trade between the United States and Russian Federation, Argentina and the United States in more recent years may explain the significant improvement in the speed of adjustment.

The same results in the beef market are repeated in the wheat market. That is, the fundamental relationship of the Australia and the U.S. wheat price significantly improved with the long-run transmission elasticity implied in the cointegrating vector increasing from 1.020 in the pre-GATT period to 1.075 in the GATT period. The speed of adjustment also increased from 0.064 to 0.414.

Furthermore, the variance decomposition analysis shows that there is a greater degree of market integration in the post-GATT period as evidenced by the more widespread and faster transmission of price variability across prices in both the beef and wheat markets. The long-run maximum proportion of the variability of the U.S. beef price (explained by unexpected shocks to the Australian beef price) has increased from 14.53 percent in the pre-GATT regime to 25.95 percent in the post-GATT regime (see table 8 and figure 2). Moreover, the speed at which the unexpected shocks to the Australian beef price are reflected in the variability of the U.S. beef price has improved significantly under the GATT regime. Whereas the maximum share of 14 percent is not reached until the tenth-step-ahead-forecast in the pre-GATT regime, the maximum share of 25 percent in the post-GATT regime is already reached as early as the second-step-ahead-forecast. Also, the long-run maximum proportion of the variability of the Australia beef price that is explained by the unexpected shocks of the U.S. beef price increased from 14.52 percent in the pre-GATT regime to 45.93 percent in the post-GATT regime (see table 8 and figure 3). However, the speed at which the unexpected shocks to the Australian beef price are reflected in the variability of the U.S. beef price has slightly slowed down from 100 percent of the maximum share reached in the fifth-step-ahead-forecast in the pre-GATT regime to only 90 percent in the post-GATT regime. The same significant improvement in the transmission of price variability can be observed in the case of wheat price.

The maximum share of shocks to the Australia wheat price to the variability of the U.S. wheat price doubled from 20 percent in the pre-GATT regime to 43 percent in the post-GATT regime (see table 9 and figure 4). The same can be said for the maximum share of shocks to the U.S. wheat price on the variability of the Australia wheat price, which more than doubled from

19 to 46 percent (see table 9 and figure 5). Whereas the maximum share is attained slowly in the pre-GATT regime for both prices, the post-GATT regime shows faster transmission of price shocks in the wheat market.

A slightly different interpretation of the variance decomposition analysis shows that there is more price simultaneity under the GATT regime, suggesting better integration of markets in both beef and wheat. In the pre-GATT regime, 85 percent of the variability of the U.S. and Australia beef price were explained by their own variability. This own-share decreased to 74 and 54 percent, respectively, in the post-GATT regime. It is also shown that while their degree of exogeneity was almost the same in the pre-GATT regime, the Australia beef price became more endogenous in the post-GATT regime. This is consistent to the fact that Australia can be considered as the residual supplier of beef in the world with a share of 43 percent of total world net beef trade in 1998. Australia’s beef net export in 1998 was 1187 tmt compared to a net import of 205 tmt for the United States.

The same pattern is repeated in the case of wheat, where in the pre-GATT regime, 80 and 81 percent of the U.S. and Australia wheat price, respectively, were explained by their own variability. Both prices showed greater endogeneity in the post-GATT regime, with the share of their own variability accounting only for 57 and 54 percent of their respective variability.

Summary and Conclusion

While the GATT revisitation is just a year away, questions are raised on the impact of GATT due to implementation maneuvers that might have frustrated the true intent of the disciplines.

This study departs from the abundant studies on GATT in both subject matter and methodology. Whereas earlier studies examined the impact of GATT mostly on economic activities, this study focused on the institutional impact of GATT, particularly on market integration and efficiency. Whereas earlier studies had to specify general or partial equilibrium structure in their models, this study used time series methods with minimum structural specification.

The world beef and wheat markets are used as specific cases to examine the impact of GATT reforms on market integration and efficiency. Major importers and exporters of beef were significantly impacted by the GATT reforms. The TRQ in beef represents 23.93 percent of world trade and is higher than that of pork and poultry. On the other hand, the volume of maximum allowable subsidized beef export is 31.20 percent of trade compared to 38.18 percent for pork. In the case of wheat, the level of maximum subsidized export representing 47 percent of world trade is reduced by 31 percent.

The impact of GATT on market integration and efficiency was analyzed using cointegration and innovation accounting to capture the degree and speed of transmission of shocks in both the fundamental variables and innovations.

An ADF test showed that all the beef and wheat prices are nonstationary. The cointegration test suggests that a long-run equilibrium exists for beef prices within the Pacific beef market, between the Pacific and Atlantic beef market, and the wheat market. The study found very strong evidence that GATT disciplines promoted market efficiency in both the world beef and wheat markets.

Long-run price transmission elasticity increased and the speed at which the market adjusted to departures from its long-run equilibrium more than doubled under the GATT regime. Within the Pacific market price, transmission elasticity between Australian and U.S. beef prices improved and adjustment toward equilibrium is much faster under the GATT regime. Between the Pacific and Atlantic beef market, GATT reforms corrected the corrupt (inverse) relationship between the Australian and Argentine beef prices, and increased the speed of adjustment. The same improvement in the price transmission elasticity and speed of adjustment is shown in the case of wheat.

Variance decomposition shows better market integration under the GATT regime, with more widespread and faster transmission of unexpected shocks across different prices in both the beef and wheat markets.

Furthermore, the variance decomposition suggests that with better market integration under the GATT regime, prices exhibit more simultaneity. That is, under GATT, a larger proportion of price variability is explained by shocks in other prices in the market than own shocks. This is particularly true for the Australian beef price since Australia can be considered the residual supplier of beef in the world.

Table 1. Percentage comparison of estimated ad-valorem tariff equivalent, 1986-88 and tariffs declared in country schedules

	Wheat			Beef		
	1986-88	UR Base	Change	1986-88	UR Base	Change
Industrial						
Australia	0.7	0.0	-0.7	0.0	0.0	0.0
Canada	30.0	57.7	27.7	2.0	38.0	36.0
United States	20.0	6.0	-14.0	3.0	31.0	28.0
EU12	103.0	155.6	52.6	83.0	125.4	42.4
Japan	651.0	239.6	-411.4	87.0	38.5	-48.5
New Zealand	0.0	0.0	0.0	0.0	0.0	0.0
Australia	188.0	400.0	212.0	79.0	239.0	160.0
Finland	239.0	352.0	113.0	193.3	394.0	200.7
Norway	266.0	495.0	229.0	145.0	405.0	260.0
Switzerland	245.0	179.0	-66.0	236.0	479.0	243.0
Turkey	36.0	200.0	164.0	-4.4	250.0	254.4
Developing						
Mexico	-1.0	74.0	75.0	41.6	50.0	8.4
Columbia	20.0	138.0	118.0		120.0	
Venezuela		130.0			50.0	
Thailand		64.0			60.0	
South Africa	10.3	74.5	64.2		210.0	
Indonesia		30.0			70.0	
South Korea		10.9		95.5	44.5	-51.0
Morocco	14.0	224.0	210.0		315.0	
Czech Rep	-38.0	16.0	54.0	134.0	43.0	-91.0

Table 2. GATT tariff quota

			Change		
Commodity	Initial TRQ	Final TRQ	Absolute	Percent	Percent of Trade
	(million metric tons)				
Beef	1,160,619	1,301,034	140,415	12.10	23.93
Pork	192,207	346,406	154,199	80.23	10.67
Poultry	195,162	247,497	52,335	26.82	6.18
Mutton	286,578	289,854	3,276	1.14	37.27

Table 3. GATT maximum allowable subsidized export

Commodity	Initial Max Sub Export	Final Max Sub Export	Change	Percent Change	Percent of Trade
			(thousand metric tons)		
Meat					
Beef	1,513	1,129	(384)	-25.38	31.20
Pork	688	560	(127)	-18.55	38.18
Poultry	802	594	(208)	-25.90	25.39
Mutton	28	23	(4)	-15.79	3.68
Wheat	56,940	39,413	(17,528)	-30.78	46.5

Table 4. Share of exports and imports to countries in the same market segment

	Export		Import	
Market	Share (%)	Volume (tmt)	Share (%)	Volume (tmt)
Atlantic Market				
Argentina	82.76	470		
Brazil	94.64	43	98.26	144
China	99.00	29	0.88	3
Czech republic	100.00	2	100.00	4
European Union	99.87	784	93.59	281
Hong Kong	100.00	3	53.29	35
India	99.09	165		
Indonesia			8.17	5
Philippines			61.14	59
Poland	100.00	28		
Romania	100.00	1		
Russia			99.51	550
Pacific Market				
Australia	90.56	678	100.00	4
Canada	99.57	241		
Japan			100.00	648
Mexico	100.00	0	100.00	96
New Zealand	94.41	344		
Taiwan			100.00	60
South Korea			99.97	140

Table 5. Augmented Dickey-Fuller test

	$\alpha_0=\alpha_T=0$		$\alpha_0\neq0,\ \alpha_T=0$		$\alpha_0\neq0,\ \alpha_T\neq0$	
	Test Stat	Cri Val	Test Stat	Cri Val	Test Stat	Cri Val
Beef Price						
United States	0.536	-1.942	-3.759	-2.882	-3.389	-3.442
Australia	-0.552	-1.942	-0.542	-2.882	-2.064	-3.442
Argentina	0.642	-1.945	-1.349	-2.904	-1.352	-3.476
Wheat Price						
United States	-0.629	-1.941	-3.552	-2.870	-3.489	-3.425
Australia	-0.321	-1.941	-2.901	-2.870	-2.987	-3.425
Argentina	-0.351	-1.941	-2.788	-2.875	-2.908	-3.431

Table 6. Johansen Cointegration test

	Maximal Eigenvalue		Trace of Stochastic Matrix	
Null and Alternative	Test Stat	Critical Value	Test Stat	Critical Value
Pacific Beef Market				
AU-US Pre-GATT				
0 vs 1	18.370	10.600	24.000	13.310
1 vs 2	5.630	2.710	5.630	2.710
AU-US Post-GATT				
0 vs 1	20.870	10.600	23.160	13.310
1 vs 2	2.290	2.710	2.290	2.710
Pacific-Atlantic Beef Market				
AU-AR Pre-GATT				
0 vs 1	20.870	10.600	23.160	13.310
1 vs 2	2.290	2.710	2.290	2.710
AU-AR Post-GATT				
0 vs 1	15.650	10.600	20.290	13.310
1 vs 2	4.640	2.710	4.640	2.710
Wheat Market				
AU-US Pre-GATT				
0 vs 1	9.870	7.370	9.900	10.350
1 vs 2	0.030	2.980	0.030	2.980
AU-US Post-GATT				
0 vs 1	22.100	7.370	29.840	10.350
1 vs 2	7.740	2.980	7.740	2.980

Significance level at 10 percent

Table 7. Long-run relationship and speed of adjustment

	Pre-GATT		GATT	
Variables	Long-run	Speed	Long-run	Speed
Pacific Beef Market				
AU-US Beef Price	0.243	0.309 4.288	0.289	0.609 4.082
Atlantic Beef Market				
AU-AR Beef Price	-0.065	0.246 4.215	0.070	0.592 4.030
Wheat Market				
AU-US Wheat Price	1.020	0.064 1.161	1.075	0.414 2.845

Table 8. Variance decomposition for the beef market

	Pre-GATT				GATT			
	US Beef Price Variability		AU Beef Price Variability		US Beef Price Variability		AU Beef Price Variability	
Step	US Price	AU Price	US Price	AU Price	US Price	AU Price	US Price	AU Price
1	100.000	0.000	0.000	100.000	100.000	0.000	0.000	100.000
2	95.799	4.201	0.038	99.962	77.135	22.865	2.669	97.331
3	95.557	4.443	2.872	97.128	74.111	25.889	11.524	88.476
4	95.003	4.997	6.288	93.712	74.976	25.024	11.609	88.391
5	94.627	5.373	6.425	93.575	72.883	27.117	14.132	85.868
6	94.204	5.796	10.454	89.546	75.183	24.817	14.058	85.942
7	88.390	11.611	12.904	87.096	75.074	24.926	23.343	76.657
8	86.627	13.373	13.146	86.854	74.769	25.231	33.868	66.132
9	86.789	13.211	13.107	86.893	74.462	25.538	33.719	66.281
10	85.977	14.023	13.898	86.102	75.478	24.522	44.446	55.554
11	85.993	14.007	14.095	85.906	74.547	25.453	45.609	54.391
12	85.472	14.528	14.525	85.475	74.054	25.946	45.930	54.070

Table 9. Variance decomposition for the wheat market

	Pre-GATT				GATT			
	U.S. Wheat Price Variability		AU Wheat Price Variability		U.S. Wheat Price Variability		AU Wheat Price Variability	
Step	U.S. Price	AU Price	U.S. Price	AU Price	U.S. Price	AU Price	U.S. Price	AU Price
1	100.000	0.000	0.000	100.000	100.000	0.000	0.000	100.000
2	90.099	9.901	9.063	90.937	64.922	35.078	53.427	46.573
3	84.401	15.599	10.788	89.212	64.763	35.237	53.493	46.507
4	82.407	17.593	10.946	89.054	63.558	36.442	54.345	45.655
5	82.288	17.712	10.971	89.029	63.723	36.277	54.591	45.409
6	81.496	18.504	10.959	89.041	63.042	36.958	55.203	44.797
7	80.401	19.599	14.196	85.804	63.490	36.510	55.668	44.332
8	80.114	19.886	14.660	85.340	61.815	38.185	55.414	44.586
9	80.271	19.729	15.952	84.048	59.155	40.845	54.550	45.450
10	80.186	19.814	15.988	84.012	58.719	41.281	54.500	45.500
11	80.325	19.675	16.381	83.619	58.567	41.433	53.773	46.227
12	79.522	20.478	18.672	81.328	56.750	43.250	53.869	46.131

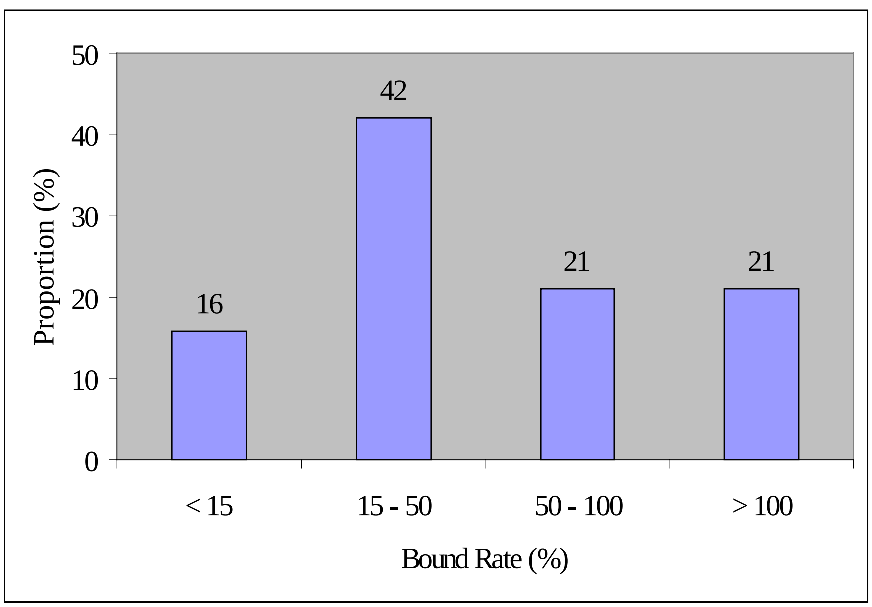

Figure 1. Proportion of countries and final bound rate for beef in GATT.

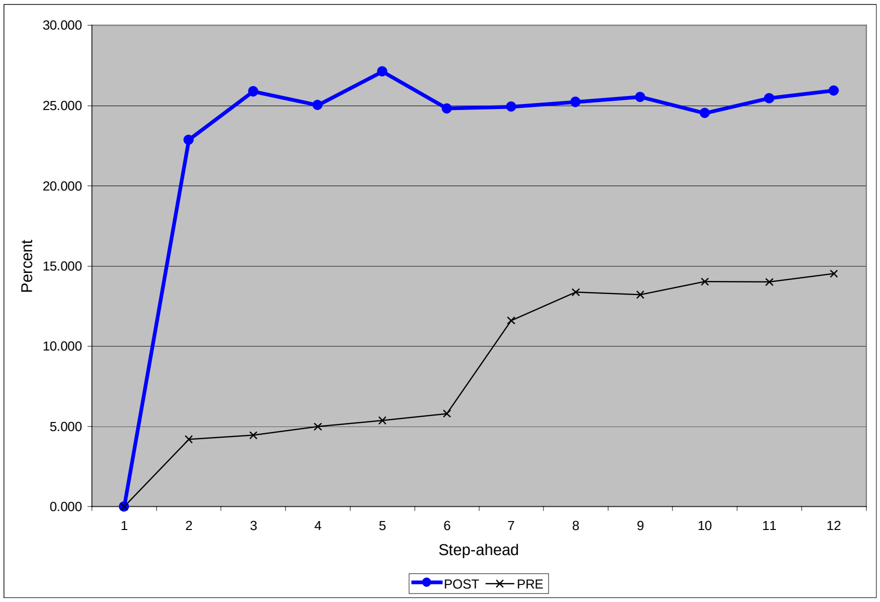

Figure 2. Share of Australian beef price innovation in the variance of U.S. beef price.

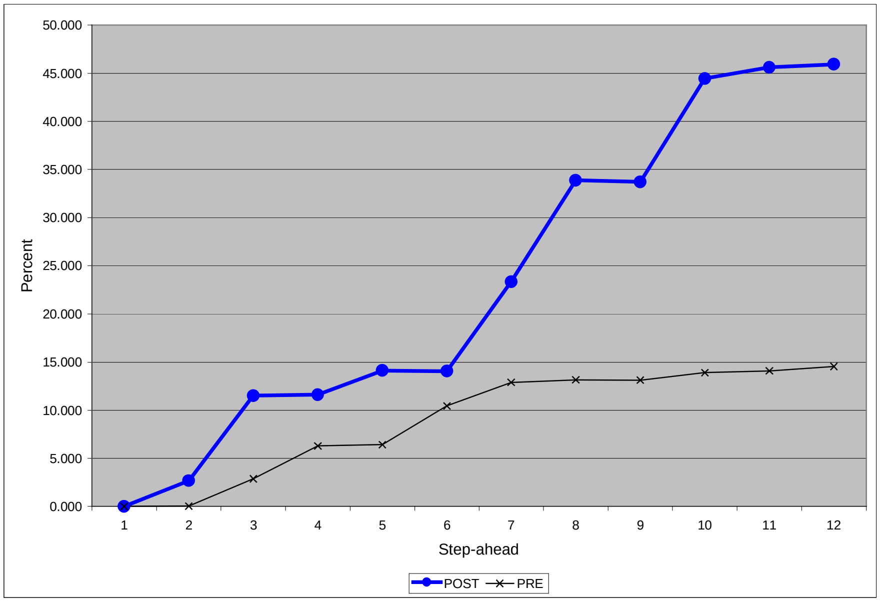

Figure 3. Share of U.S. beef price innovation in the variance of Australian beef price.

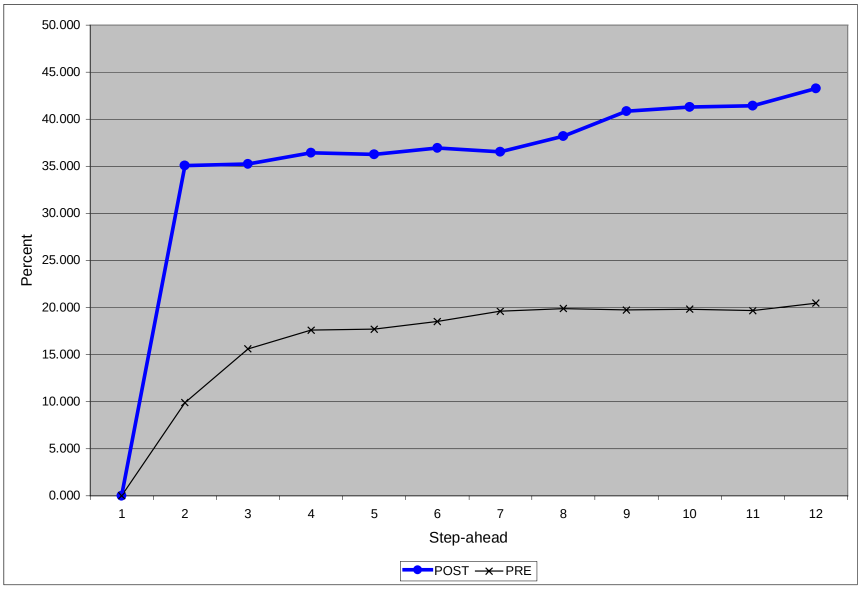

Figure 4. Share of Australian wheat price innovation in the variance of U.S. wheat price.

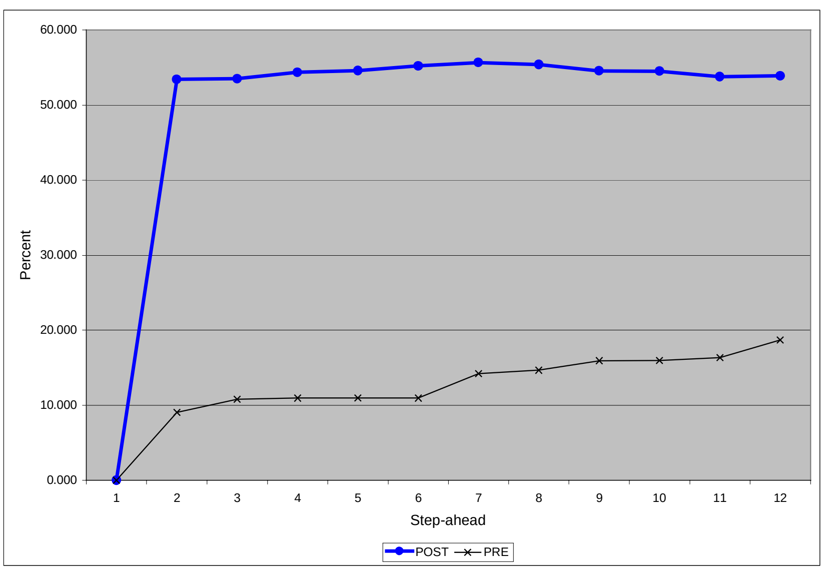

Figure 5. Share of U.S. wheat price innovation in the variance of Australian wheat price.

Acronyms and Abbreviations

ABARE	Australian Bureau of Agricultural Resource Economics
ADF	Augmented Dickey Fuller Test
AMS	Aggregate Measure of Support
CIF	cost of insurance and freight
EU	European Union
FAPRI	Food and Agricultural Policy Research Institute
MAV	Minimum Access Volume
NAFTA	North American Free Trade Agreement
OECD	Organization of Economic Cooperation and Development
RATS	Regression Analysis of Time Series
USDA	U.S. Department of Agriculture

References

Benson, B.L., M.D. Faminow, M.H. Maquis, and D.G. Sauer. (1994). "The Impact of Provincial Marketing Boards on Price Relationships and Pricing Dynamics in North American Slaughter Hog Market." *Applied Econometrics* 26:677-88.

Bewley, K., and D.G. Fiebeg. (1989). "Why Are Long-Run Parameter Estimates So Disparate?" Discussion Paper No. 89/3. University of New South Wales School of Economics.

Borges, R.B. (1995). "Trade and the Political Economy of Agricultural Policy: The Case of the Unites States Peanut Program." *Journal of Agriculture and Applied Economics* 27(2):595-612.

Brester, G.W., and M.K. Wohlgenant. (1997). "Impacts of the GATT/Uruguay Round Trade Negotiations on U.S. Beef and Cattle Prices." *Journal of Agriculture and Resource Economics* 22(1):145-56.

Campbell, J.Y., and P. Perron. (1991). "Pitfalls and Opportunities: What Macroeconomists Should Know About Unit Roots." *NBER Macroeconomics Annual 1991*. Cambridge: The MIT Press.

Dickey, D.A., D.W. Jansen, and D.I. Thornton. (1991). A Primer on Cointegration with an Application to Money and Income. Federal Reserve Bank of St. Louis.

Doan, T.A. (1990). RATS User's Manual Version 4.

Engle, R.F., and C.W.J. Granger. (1987). "Cointegration and Error Correction: Representation, Estimation, and Testing." *Econometrica* 55:251-76.

Engle, R.F., D.F. Hendry, and J. Richard. (1983) . "Exogeneity." *Econometrica* 51:277-305.

Fausti, S.W., and B.A. Qasmi. (1998). The Effect of NAFTA on Trade in Agricultural Food Products. Research Discussion Paper No. 13. Trade Research Center, Montana State University.

Fuller, F., and D. Hayes. (1998). The Impact of Chinese Accession to the World Trade Organization on U.S. Meat and Feed-Grain Producers. Research Discussion Paper No. 16. Trade Research Center, Montana State University.

Goodwin, B.K. (1992). “Multivariate Cointegration Tests and the Law of One Price: A Clarification and Correction.” *Review of Agricultural Economics* 14:337-38.

Goodwin, B.K., and T.J. Grennes. (1994). “Real Interest Rate Equalization and the Integration of International Financial Statistics.” *Journal of International Money and Finance*, 13:107-24.

Granger, C.W.J. (1969). “Investigating Causal Relationships by Econometric Models and Cross Spectral Methods.” *Econometrica* 37:424-38.

Granger, C.W.J., and P. Newbold. (1974). “Spurious Regressions in Econometrics,” *Journal of Econometrics* 2:111-20.

Gunter, L.F., K.H. Jeong, and F.C. White. (1996). “Multiple Policy Goals in Trade Model with Explicit Factor Market.” *American Journal of Agricultural Economics* 78(2):313-30.

Helmar, M., V. Premakumar, K. Oerter, J. Kruse, D.B. Smith, and W.H. Meyers. (1994). Impacts of the Uruguay Round on Agricultural Commodity Markets. Research paper 94-GATT 21, Center for Agricultural and Rural Development, Iowa State University.

Ingco, M.D. (1995). Agricultural Trade Liberalization in the Uruguay Round: One Step Forward, One Step Back? Supplementary paper for the *Conference on the Uruguay Round and the Developing Economies.* International Trade Division, The World Bank.

Johansen, S. (1988). “Statistical Analysis of Cointegration Vectors.” *Journal of Economic Dynamics and Control* 12:231-54.

Marsh, J.M. (1997). GATT Policies and Effects on the U.S. Beef Market. Research Discussion Paper No. 5. Trade Research Center, Montana State University.

McNew, K., and P.L. Fackler. (1997). Testing Market Equilibrium: Is Cointegration Informative?” *Journal of Agricultural and Resource Economics* 22(2):191-207.

Miljkovic, D., G.W. Brester, and J.M. Marsh. (1998). Pricing to Market of U.S. Meat Exports. Research Discussion Paper No. 26. Trade Research Center, Montana State University.

Nelson and Plosser. (1982). Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications.” *Journal of Monetary Economics* 10:139-62.

Oerter, K., M. Helmar, V. Premakumar, J. Kruse, D.B. Smith, and W.H. Meyers. (1995). Impacts of the Uruguay Round on the World Rice Market. Research paper 95-GATT 1. Center for Agricultural and Rural Development, Iowa State University.

Silvapulle, P., and S. Jayasuriya. (1994). "Testing for Philippine Rice Market Integration: A Multiple Cointegration Approach." *Journal of Agricultural Economics* 45:369-80.

SAS Institute Inc. (1993). *SAS/ETS User's Guide*. Version 6, Second Edition. Cary, NC: SAS Institute Inc.

Song, J.H., and C.A. Carter. (1996). "Rice Trade Liberalization and Implications for U.S. Policy." *American Journal of Agricultural Economics* 78(4):891-905.

U.S. Department of Agriculture. Economic Research Service (ERS). (1998). Uruguay Round Agreement on Agriculture: The Record to Date. Special article in the Agricultural Outlook.

U.S. Department of Agriculture. Foreign Agriculture Service (FAS). (1998). Livestock Annual Report. Various countries and various issues.

Veeman, M. (1994). "Implications of NAFTA and GATT for the Canadian Red Meat Sector." *Canadian Journal of Agricultural Economics* 42(4):473-83.

World Trade Organization. (1995). Annual Report: International Bovine Meat Agreement. Geneva: World Trade Organization.