Impact of GATT in the Functioning of Agricultural Markets: An Examination of Market Integration and Efficiency in the World Beef and Wheat Market Under the pre-GATT and post-GATT Regimes[1]

Jacinto F. Fabiosa
Center for Agricultural and Rural Development
Iowa State University
Ames, Iowa

Correspondence to: J. Fabiosa, Center for Agricultural and Rural Development, Iowa State University, Ames, IA, 50011-1070, USA. Phone: (515) 294-6183. FAX: (525) 294-6336. E-Mail: jfabios@gcard.iastate.edu.

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Abstract

Although the GATT compliance record is mixed, this study finds consistent evidence that GATT reforms improved market efficiency and integration in the beef and wheat market. Cointegration analysis shows much improved price transmission and speed of adjustment. Variance decomposition analysis reveals larger and quicker impacts in prices of non-fundamental shocks originating from other markets. Results make a stronger case for more reforms in the current revisitation of the Agreement.

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1. Introduction

The historic Uruguay Round Agreement on Agriculture (URAA) accomplished what has eluded the GATT for a long time, that of putting trade in agriculture under the same umbrella of disciplines 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.

With the end of the six-year implementation period and the start of its revisitation this year, the GATT compliance record so far is mixed at best. Despite the conversion of non-tariff barriers (NTBs) into tariff equivalents that were to be cut by 24 to 36 percent, and MAV insured access at a minimum of 3 to 5 percent of base consumption, “dirty tarriffication” limited the reduction in effective protection. Although AMS declined by 40 percent, which is much higher than the 13 to 20 percent required in the URAA, support under the “green-box” increased by 54 percent. With all these shortcomings, did GATT make any difference in agricultural trade at all?

Studies on the impact of GATT is abundant in the literature. However, they have mostly focused on the impact of GATT on economic activities such as production, consumption, trade, and prices (Brester and Wohlgennant (1997), Fuller and Hayes (1998)). 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 (i.e., changes on “rules of the game”) in nature. The impact on economic activities in some sense is secondary since it largely relies on the institutional change aspect of GATT.

This is where this study departs from earlier studies. In particular, 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 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 was highly protected with measures that impeded market integration and efficiency that were subject to reforms under the URAA. 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.

The URAA disciplines radically changed domestic and trade policies of several countries that are significant players in the world beef market. The EU, the fourth largest beef importer of the world ended its variable levy in beef, allowed tariff quota of 161 tmt at an in-quota rate of 20 percent, and limited export subsidy to 822 tmt until 2000. The U.S. replaced its quota under the Meat Import Law with a TRQ of 657 tmt. Japan, the second largest importer of beef in the world, abolished its beef import quota in a 1990 agreement and replaced its base rate of 93 percent to 50 percent bound rate effective in 1995 to further decline to 38.5 in the year 2000. Mexico the sixth largest importer liberalized its imports of fresh/chilled/frozen beef import since January 1994, courtesy of the NAFTA agreement, and full liberalization of beef variety meats will follow by 2003. Although South Korea, the seventh largest importer, is fully liberalizing their beef imports only 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.[2]

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 of it subsidized, it had to operate within the maximum allowable subsidized wheat export of 16.8 mmt in 1998/98.

2. Model

This study also departs from earlier studies on GATT in the methodology used. 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 used the concept of cointegration to test for market integration such as Goodwin (1992), Goodwin and Grennes (1994), Benson et al. (1994a), and Silvpulle 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]

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[2] Another feature of the world beef market that impeded on market efficiency is its segmentation into the Pacific and Atlantic beef market, 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

[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 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 Ψ is full then using levels in [2] presents no statistical problem. On the other hand, if the rank of Ψ is zero then a difference version of [2] is adequate. However, if the rank of Ψ is $0 < r < N$ then the ECM in [3] is the appropriate model. If [2] is used, then any statistical test is suspect, while if a difference version is used, then misspecification error is committed by ignoring the long-run term.

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

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export frozen, fresh, and chilled beef products to FMD-free countries. Australia and the U.S. are major players in the Pacific market, while Argentina and the EU are the major players in the Atlantic market.

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 ith equation of [4] is

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

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

where σ_i^2 is the variance of the innovation of the ith 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 ith good is

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

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

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

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

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

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

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

3. 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. dollar per pound. U.S. beef price is FOB New York, while Australia and Argentina beef price are CIF in U.S. East Coast port. Wheat prices are in U.S. dollar per bushel. 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 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 1 shows that 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 can not reject the null hypothesis of nonstationarity . This means that the individual price series can wander away with no tendency to revert back 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 back 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 Australia beef price. Table 2 shows that the Johansen test suggests two cointegrating vectors between the Australia 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 Australia and Argentina beef price. The Johansen test suggests one cointegrating vector between the Australia and Argentina beef price in the pre-GATT period and two cointegrating vector in the post-GATT period. The same result is shown for the long-run relationship of the Australia and U.S. wheat prices. Since the result on the number of cointegrating vector 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 by many countries to frustrate the true intent of the URAA. Table 3 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, when the U.S. and Australia beef prices departed from their long-run equilibrium relationship, the Pacific beef market has become 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 t-ratio of 4. Even the fundamental relationship of beef price between the segmented Pacific and Atlantic beef market 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 even under GATT in the Pacific-Atlantic beef market compared to the within Pacific market may be explained by the continuing segmentation of the two markets, which might have even been strengthened under the GATT agreement on sanitary and phytosanitary measures. However, the increasing across-market beef trade between the U.S. and Russian Federation, Argentina and the U.S. 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 Australia and 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 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 that is explained by the unexpected shocks of 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 4). Moreover, the speed at which the unexpected shocks in 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 10th-step-ahed-forecast in the pre-GATT regime, the maximum share of 25 percent in the post-GATT regime is already reached as early as the 2nd-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. However, the speed at which the unexpected shocks in 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 5th-step-ahed-forecast in the pre-GATT regime to only 90 percent of the maximum share is reached in the same forecast 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 in 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 5). The same can be said for the maximum share of shocks of U.S. wheat price on the variability of the Australia wheat price which more than doubled from 19 to 46 percent. 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 in the result 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 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.

4. Summary and Conclusion

While the GATT revisitation has been bogged by many issues, the central question to raise is "Did GATT make a difference?"

Although studies on GATT are abundant in the literature, this study departs from them 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 were used as specific cases to examine the impact of GATT reforms on market integration and efficiency. Major importers and exporters of beef in the world were significantly impacted by the reforms under GATT. The same can be said in the case of the world wheat market.

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 fundamentals and innovations.

An ADF test showed that all the beef and wheat prices are nonstationary. Cointegration test suggests that a long-fun 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 Australia and U.S. beef price 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 price, 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 to the Australia beef price since it can be considered as the residual supplier of beef in the world.

Table 1. 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 2. Johansen Cointegration test

	Maximal Eigenvalue		Trace of Stochastic Matrix	
Null and Alternative	Test Stat	Critival Value	Test Stat	Critival Value
Beef 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
Beef 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
Wheat 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
Wheat 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 3. 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 4. 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 5. Variance decomposition for the wheat market

	Pre-GATT				GATT			
	US Wheat Price Variability		AU Wheat Price Variability		US Wheat Price Variability		AU Wheat 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	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

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