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Technical Annex

Analyzing Effects of the U.S. Duties on Canadian Hard Red Spring Wheat

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This document is the technical annex to the full paper "Analyzing Effects of the U.S. Duties on Canadian Hard Red Spring Wheat" which is available separately.

Development of an Empirical Model

To examine the effect of the antidumping and countervailing duties on U.S. price, we first derive a price model by relying on the theoretical framework developed by Westcott and Hoffman (1999). In its simplest form this model specifies demand for wheat (D) as a function of prices in the current (P) and previous (P_{t-1}) periods. Supply of wheat (S) is a function of prices in the previous period (P_{t-1}). Wheat stocks (SK) are a function of prices (P).

(1) $D = f(P, P_{t-1}, E)$; $S = f(P_{t-1}, E)$; and $SK = f(P, E)$

(2) $S - D - SK = 0$

where E is a vector of exogenous variables. The market equilibrium condition determines the price of wheat at which supply equals demand plus wheat stocks. In equilibrium, therefore, the price of wheat can be specified as a function of wheat stocks:

(3) $P = f(SK, E)$

The components of supply (S) include beginning stocks (BS), production ($PROD$), and imports (M). Major elements of demand (total use) (D) are domestic consumption (DC) and exports (X). Using the two identities, equation 2 can be rewritten as follows:

(4) $(BS + PROD + M) - (DC + X) - SK = 0$

The stocks-to-use ratio is commonly used as a proxy for stocks of a commodity to represent market conditions in explaining price movements (e.g., Baker and Menzie, 1988; Westcott and Hoffman, 1999). This ratio is defined as the ending stocks ($BS + PROD + M - DC - X$) divided by total use ($DC + X$). In this study, however, we separate these components into supply (S), domestic consumption (DC), and exports (X), which allows us to estimate *ceteris paribus* effects of the three variables on wheat price. In addition, although the United States is one of the largest wheat exporters in the world market, its role in price setting is not dominant due to other major competitors (e.g., the EU, Canada, Australia, and Argentina). As a result, U.S. domestic wheat prices could be influenced by world market conditions. To incorporate the global market effect, the foreign stocks-to-use ratio (FSU) is added to the model (Westcott and Hoffman, 1999). A lagged-prices variable (P_{t-1}) is also added to capture dynamic effects.[1] Equation 3 now can be rewritten as follows:

(5) $$P^w = f(S^w, DC^w, X^w, FSU, P_{t-1}^w)$$

where superscript w represents an index for wheat type: $w=1$ for HRS wheat and $w=2$ for HRW wheat. It should be emphasized that, as noted in the introduction, the antidumping and countervailing duties on Canadian HRS wheat are expected to push U.S. prices of both HRS and HRW wheat to increase, since these two classes of wheat are highly substitutable in consumption. For this reason, we develop two price models for HRS and HRW wheat to measure the impacts of the duties accurately. With respect to the signs of the coefficients, supply is expected to have a negative effect on price, while exports and domestic consumption should positively affect price. Finally, an increase in the supply or decrease in the use of wheat in the rest of the world is expected to have a negative effect on U.S. price.[2]

In addition, a U.S. export model for HRS wheat is developed to take into consideration the possibility that the diversion of Canadian exports from the U.S. market to offshore markets could have a negative impact on U.S. offshore exports (third-country effects). For this purpose, we modify the third-country effect model of wheat developed by Jin, Cho, and Koo (2004) to represent the interaction between U.S. HRS wheat exports and Canadian HRS wheat exports to offshore markets. A U.S. export equation is specified as a function of Canadian HRS wheat offshore exports (CX^{hrs}), U.S. exportable supply (XS^{hrs}), the U.S. trade-weighted exchange rate for wheat importing countries (ER^{us}), the U.S.-Canada bilateral exchange rate (ER^{ca}), and the U.S. export price (XP^{hrs}). Since Canada produces only HRS wheat, we specify the U.S. export equation for only HRS wheat as follows:

(6) $$X^{hrs} = h(CX^{hrs}, XS^{hrs}, ER^{us}, ER^{ca}, XP^{hrs})$$

where XS^{hrs} is defined as domestic supply ($BS + PROD$) minus domestic use (DC). It is expected that an increase in Canadian offshore exports should have a negative impact on U.S. exports. An appreciation of the U.S. dollar relative to importing countries' currencies should have a negative effect on U.S. exports, because U.S. wheat would become more expensive in those countries. An appreciation of the U.S. dollar relative to the Canadian dollar should also negatively affect U.S. exports, because U.S. wheat would become more expensive compared to Canadian wheat. Finally, an increase in U.S. export price (XP^{hrs}) or U.S. exportable supply (XS^{hrs}), stemming from an increase in production or decrease in domestic consumption, is expected to positively influence U.S. exports.

Before estimating the models, the important specification issue to be addressed is the determination of possible endogeneity of an independent variable in equation 5. More specifically, estimating the price model with direct estimation methods such as ordinary least squares (OLS) requires the independent variables to be exogenous; otherwise, the OLS estimator is less efficient than with an instrumental variable method (e.g., two/three-stage least squares) (Wooldridge, 2000). In our case, therefore, it is necessary to have a test for endogeneity of two suspected independent variables – domestic consumption (DC^{w}) and supply (S^{w}) – in equation 5. For this purpose, we use the Durbin-Wu-Hausman (DWH) test, which was proposed in its general form in Hausman (1978). The results show that the null hypothesis of exogenous variable can be rejected at the 1 percent level for DC^{w}. However, the null hypothesis cannot be rejected even at the 10 percent level for S^{w}. These results lead to the conclusion that the domestic consumption can be treated as an endogenous variable.[3] As such, a domestic consumption equation is specified as a function of spring wheat and winter wheat prices as follows:

(7) $$DC^{w} = g(P^{hrs}, P^{hrw})$$

where P^{hrs} and P^{hrw} are the prices of HRS wheat and HRW wheat. The price of HRS wheat should have a negative effect on domestic HRS wheat consumption, while the price of HRW wheat should be positively related to spring wheat consumption since it is a substitute. Conversely, an increase in the HRS wheat price should lead to increased HRW wheat consumption, and an increase in the HRW wheat price should lead to a decrease in HRW wheat consumption.

For our empirical analysis, equations 5-7 are expressed in a log linear functional form as follows:

(8) $$\ln P_t^{w} = \alpha_0 + \alpha_1 \ln S_t^{w} + \alpha_2 \ln DC_t^{w} + \alpha_3 \ln X_t^{w} + \alpha_4 \ln FSU_t + \alpha_5 \ln P_{t-1}^{w} + \alpha_6 t + \varepsilon_t$$

(9) $$\ln X_t^{hrs} = \beta_0 + \beta_1 \ln CX_t^{hrs} + \beta_2 \ln XS_t^{hrs} + \beta_3 \ln ER_t^{us} + \beta_4 \ln ER_t^{ca} + \beta_5 XP_t^{hrs} + \beta_6 t + u_t$$

(10) $$\ln DC_t^{w} = \gamma_0 + \gamma_1 \ln P_t^{hrs} + \gamma_2 \ln P_t^{hrw} + \gamma_3 t + \nu_t$$

where α, β, and γ are coefficients to be estimated; ε, u, and ν are i.i.d. error terms; and t is a trend variable that is added to capture technical change and changes in consumer preferences. Equations 8-10 are estimated simultaneously using the three-stage least squares (3SLS) estimator for HRS wheat, while equations 8 and 10 are estimated using 3SLS for HRW wheat. As noted above, with recognizing the endogeneity of domestic consumption (DC^w) in both HRS and HRW models, unlike OLS, 3SLS provides consistent estimates of the parameters. In addition, 3SLS is a full-information estimation technique that estimates all parameters simultaneously, as well as corrects for contemporaneous correlation between the error terms in the equations. As such, 3SLS produces more efficient estimators than 2SLS (Darnell, 1994).

Data Sources and Testing for Unit Roots

The HRS and HRW prices are the Minneapolis Dark Northern Spring 14 percent protein cash price and the Kansas City HRW #1 13 percent protein cash price, respectively, which are obtained from the USDA from the Economic Research Service's (ERS) *Wheat Yearbook* and issues of the ERS's *Wheat Outlook*. Monthly stocks and use projections from the USDA's World Agricultural Supply and Demand Estimates (WASDE) are used for HRS and HRW wheat and foreign wheat (available at http://usda.mannlib.cornell.edu/reports/waobr/wasde-bb/). Note that the foreign stock-to-use variable is calculated using all wheat obtained from the WASDE, because data specific to HRS and HRW wheat are not available. Data for Canadian exports to offshore markets are obtained from Statistics Canada's CANSIM database (available at http://cansim2.statcan.ca/). Exchange rate data used are the U.S. trade-weighted real exchange rate with wheat importing countries and the U.S.-Canada real exchange rate, which are taken from ERS (available at http://www.ers.usda.gov/Data/exchangerates/). Export price data, defined as the unit value of U.S. hard wheat exports, are obtained from the USDA's U.S. Trade Internet System (available at http://www.fas.usda.gov/ustrade/). Finally, the consumer price index (2000=100) obtained from the Bureau of Labor Statistics (BLS) in the U.S. Department of Labor (DOL) (available at http://www.bls.gov/cpi/home.htm) is used to derive real HRS and HRW prices and export price. The sample spans the period of January 1996-September 2003. Note that all the data used in the analysis are monthly data except when only annual data are available. Data for supply and domestic consumption for HRS and HRW wheat, and U.S. HRS wheat exports are annual, so the values for each of these variables are constant throughout the 12 months of the year.

When dealing with time-series data, the possibility of a unit root in a series raises issues about parameter inference and regression properness of structural modeling (Wooldridge, 2000). That is, when data are non-stationary, regression involving the series no longer provides the valid interpretations of the standard statistics such as t- and F-statistics due to violation of the weak dependence requirement. In addition, unless non-stationary series combine with other non-stationary series to form a stationary cointegration relationship, the estimation can misrepresent the existence of a meaningful economic relationship (i.e., spurious regression) (Harris and Sollis, 2003). Before estimating equations 8-10, the existence of a unit root is thus determined using the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test (table A1). Both the ADF and PP test statistics are estimated from a model that includes a constant and a trend variable. Akaike Information Criteria (AIC) and Schwartz Information Criteria (SIC) are used to determine lag lengths for the unit root test. The results show that the levels of 4 of the 14 variables – FSU, ER^{us}, ER^{ca} and XS^{hrs} – are non-stationary, while the first differences of the four variables are stationary, indicating that the four variables are non-stationary $I(1)$ processes. To avoid problems of parameter inference and spurious regression, therefore, we use the first difference of the four non-stationary variables to estimate the wheat models.

Table A1 Results of Unit Root Tests

Variable	*ADF test*		*PP test*	
	Statistic	Lag	Statistic	Lag
HRS wheat price	-3.47**	1	-3.49**	3
HRW wheat price	-3.65**	1	-3.65**	3
Total supply of HRS	-3.48**	2	-3.84**	3
Total supply of HRW	-3.69**	3	-4.86**	3
Domestic consumption of HRS	-3.89**	3	-3.57**	3
Domestic consumption of HRW	-3.95**	4	-3.81**	3
HRS exports	-3.64**	2	-3.89**	3
HRW exports	-3.66**	4	-3.51**	3
Foreign stocks to use	-2.29	4	-2.27	3
Canadian offshore exports	-3.81**	1	-3.67**	3
Exchange rate with importers	-2.91	2	-2.92	3
Exchange rate with Canada	-0.12	2	-0.58	3
Exportable supply	-2.61	1	-2.75	3
Export price	-3.94**	1	-3.54**	3

Note: ADF and PP tests represent Augmented Dickey-Fuller and Phillips-Perron tests, respectively. ** denotes rejection of the null hypotheses of a unit root at the 5% level. Akaike Information Criteria (AIC) and Schwartz Information Criteria (SIC) are used to determine lag lengths for the unit root test. The 5% critical value for both the ADF and PP, including a constant and a trend, is -3.46.

Empirical Results

The 3SLS estimator is used to estimate the HRS and HRW wheat models (table A2). Overall, the models fit well. The system weighted R^2 is quite high, above 0.8, indicating promising explanatory power of the models. In addition, the Durbin-Watson (DW) or Durbin h-statistics indicate that the hypothesis of no serial correlation cannot be rejected at the 5 percent level.[4] More importantly, the estimated coefficients have the expected/acceptable signs, and most of them are statistically significant at least at the 10 percent level.

The results show that total supply, consisting of both domestic production and imports, has a significant negative effect on HRS and HRW wheat prices, while domestic consumption and exports have significant positive effects on price. However, it is found that the foreign stocks-to-use ratio has little impact on HRS and HRW wheat prices. In addition, domestic consumption of HRS (HRW) wheat is negatively (positively) related to HRS wheat price, but positively related to HRW (HRS) wheat price; that is, own-price elasticities are negative, while cross-price elasticities are positive. This finding suggests that the two wheat classes are substitutable in consumption. Note that the trend variables have significant negative effects on prices and domestic consumptions of HRS and HRW wheat, but the coefficients imply only very small effects.[5] Finally, the estimated coefficients of the export equation show that Canadian offshore exports have a negatively significant effect on U.S. HRS wheat exports. This suggests that increases in Canadian exports to offshore markets instead of to the United States indeed lead to a reduction in U.S. exports to offshore markets. U.S. exports are found to increase when exportable supply or export price increases, but exchange rates are not found to be significant.

Table A2 Estimation Results of U.S. Wheat Price, Domestic Consumption, and Export Equations for U.S. HRS and HRW Wheat

Equation	*Explanatory variable*	*HRS wheat* Coefficient	*t*-value	*HRW wheat* Coefficient	*t*-value
Price	Intercept	1.24	1.20	3.85	6.47**
	Total supply	-0.58	-3.12**	-0.27	-1.96*
	Domestic consumption	0.20	2.76**	0.39	3.31**
	Exports	0.37	5.30**	0.19	2.33**
	Foreign stocks to use	0.01	0.11	-0.04	-0.47
	Lagged price	0.60	7.61**	0.64	9.52**
	Trend	-0.002	-3.35**	-0.002	-5.26**
Domestic Consumption	Intercept	6.05	4.88**	6.99	8.63**
	HRS wheat price	-1.33	-4.82**	1.03	3.15**
	HRW wheat price	1.12	4.35**	-1.21	-6.60**
	Trend	-0.001	-2.23**	-0.004	-11.4**
Export	Intercept	4.01	19.1**		
	Canadian offshore exports	-0.05	-2.75**		
	Exchange rate with importer	-0.79	-1.33		
	Exchange rate with Canada	0.59	1.33		
	Exportable supply	0.43	2.30**		
	Export price	0.34	8.63**		
	System weighted R^2	0.93		0.83	

Note: ** and * denote significance at the 5% and 10% levels, respectively.

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Endnotes

1. Including lagged prices in a price model is particularly important for such crops as wheat and corn used for livestock feeding, because livestock production decisions made in previous periods and corresponding to prices in those periods affect feed demand for years to come (Westcott and Hoffman, 1999).
2. Government programs such as the loan rate and the level of government-owned stocks have been shown to also affect wheat price (Westcott and Hoffman, 1999). For our study period (1996-2003), however, these factors are not significant. For example, the loan rate was mostly constant ($2.58/bushel) during this period. Additionally, the level of government-owned stocks was relatively insignificant (an annual average of 97 million bushels) compared to the levels of the 1980s (an annual average of 360 million bushels) when they may have affected prices. As such, these factors are excluded from the model.
3. An endogenous variable is defined as an independent variable in a (multiple) regression model that is correlated with the error-term, either because of an omitted variable, measurement error, or simultaneity (Wooldridge, 2000). Additionally, for annually produced commodities such as corn and wheat, total supply is generally specified as a function of the previous year's price, while demand is mainly specified as a function of prices in the current period (equation 1). In our case, therefore, unlike domestic consumption, total supply may be found to be exogenous because of the lagged relationship between P_{t-1}^{w} and S_{t}^{w}.
4. Note that the Durbin h-statistic is used to detect serial correlation when a lagged dependent variable is used as an explanatory variable, as seen in our HRS and HRW price models (equation 8).
5. A time trend variable in the export equation of the HRS wheat model and seasonal dummy variables in the HRS and HRW wheat models are not significant and are dropped from the final models.