Contemporaneous Correlation and Modeling Canada's Imports of U.S. Crops

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Abstract. *A multicrop model of Canadian demand for U S crops is estimated with Zellner's seemingly unrelated regression (SUR), which corrects for the distortion problem in contemporaneous correlation, and with ordinary least squares (OLS), which ignores the problem Comparing inference parameters, trade elasticity estimates, and out-of-sample forecast performance of the Canadian import demand model's SUR and OLS versions demonstrates the importance of addressing contemporaneous correlation, even though both estimators are unbiased This article addresses three shortcomings of the agricultural trade literature frequent failure to account for easily corrected econometric problems, excessively wide ranges of trade parameter estimates, and frequent failure by researchers to validate models beyond the sample*

Keywords. *Canadian imports, wheat, corn, contemporaneous correlation, Zellner's seemingly unrelated regression, ordinary least squares, price elasticities of import demand, forecast performance*

U S -Canadian agricultural trade has increased in importance with the 1988 ratification of the North American Accord by the U S Congress and the Canadian Parliament The accord is a trade liberalization pact which will "modify or sweep away a wide range of restrictions on transborder commercial and financial dealings" (*11*, p 16, *18*) [1] A symposium, 'Farm Policy for a Freer Trade World," was held May 4-6, 1988, in Quebec, which brought together hundreds of agricultural trade experts to discuss trade liberalization issues, especially between the United States and Canada This symposium reflects the heightened professional interest in U S -Canadian agricultural trade This interest should help recall the criticism of the profession for ignoring such a frequently encountered, easily corrected, and performance-distorting econometric problem as contemporaneous correlation (*2, 10*)

I demonstrate how failing to correct for contemporaneous correlation among seemingly unrelated Canadian demands for U S cotton, rice, and soybeans (hereafter called the model) influences the model's estimate efficiency (and, hence, inference parameters), point estimates, and forecast accuracy beyond the sample (model performance) Researchers involved with U S -Canadian agricultural trade employ inference parameters to analyze policy pertinent parameter estimates, use parameter estimates to ascertain consequences of policy proposals, and compare forecasts to evaluate policy alternatives I demonstrate that correcting for contemporaneous correlation greatly influences the Canadian import model's performance

Researchers should ultimately correct for all supply side and demand-side econometric problems, such as contemporaneous correlation, serial correlation, and simultaneous equations bias through proper econometric method This article focuses on the impacts on model performance of a single and specific econometric problem, contemporaneous correlation, confronting U S -Canadian flows of the three crops

Contemporaneous correlation often characterizes sets of economic relationships and occurs when the relationships, despite different sets of explanatory variables, have "disturbances correlated at a given point in time [and] not correlated over time" (*6*, pp 245-6) Sets of such equations are often called "seemingly unrelated " Contemporaneous correlation arises from omission of variables which are of indirect, rather than direct, relevance to the study Albeit unbiased, OLS estimates of seemingly unrelated equations are of questionable efficiency because the information inherent in the equations' contemporaneously correlated errors is neglected (*2, 7, 8*) Seemingly unrelated equations are appropriately estimated with Zellner's SUR Without autocorrelation and lagged endogenous regressors, SUR estimates of seemingly unrelated equations are unbiased, asymptotically consistent, and efficient (*7, 8*) Kmenta (*8*) suggests that SUR estimates have small-sample properties similar to the asymptotic ones

Forecast errors are for out-of-sample predictions, throughout Analysis of forecast errors is in terms of absolute value of such errors A coefficient denotes regression estimates of the coefficient's true value A standard error estimate denotes the sample estimate of the standard error of the estimated coefficient

Scenario Design

I estimate Canadian demands for U S supplies of cotton, rice, and soybeans with SUR and OLS SUR corrects for the equations' contemporaneous correlation,

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[1]Italicized numbers in parentheses cite sources listed in the References at the end of this article

while OLS ignores the problem I analyze the SUR/OLS differences in standard error estimates to discern the efficiency gains from correcting for contemporaneous correlation I then analyze the SUR/OLS differences in the equations' own-price elasticities to ascertain how the model's contemporaneous correlation influences trade parameter point estimates Using the information on the model's contemporaneous correlation enhances, or fails to impede, forecast accuracy in most cases

Data and the Estimated Model

Basic trade theory posits a nation's import demand for a commodity as an excess demand, that is, the difference between domestic demand and domestic supply Excess demands thus contain both domestic demand and domestic supply arguments I formulated the three Canadian demands for U S crops as Marshallian demands, without domestic supply-side variables, for two reasons because Canada imported the three crops almost exclusively from the United States from 1965-82 and because Canada produced little or none of those crops (*1, 14, 15, 16, 17*)

I estimated Canadian demands for U S cotton and soybeans with SUR and OLS, using 1965-82 annual data from Agriculture Canada (*1*) Estimated are SUR and OLS versions of a Canadian import demand for U S rice by using 1965-82 annual data from the U S Department of Agriculture (USDA) (*17*) Observations for 1983, 1984, and 1985 were saved for forecasting

All prices reflect deflated Canadian dollars Nominal prices used in conversions to denominations of deflated Canadian dollars mirror calendar year data from the International Monetary Fund (IMF) (*5*) for the U S cotton price (10 markets), U S rice price at New Orleans, price of Canadian wheat, and price of U S soybeans The real polyester price is included in the Canadian cotton relation based on previous work (*2, 3, 4*) The nominal polyester price published by USDA is converted to deflated Canadian dollars (*12*)

I initially included several region- and event-specific indicator variables in line with previous research (*2, 3, 4*) Taking a unity value for 1971-72 and a zero otherwise, X7172 (table 1) captures the influences of the initial stages of breakdown in the Bretton-Woods system of fixed exchange rates Following Duffy, I included X78, a variable valued at 1 0 after 1977 and at zero prior to 1978 (see *4*) This variable captures the Organization of Petroleum Exporting Countries' (OPEC) real crude petroleum price increases of the late 1970's

I included the IMF's (*5*) index of Canadian hourly wages as the Marshallian income variable This wage variable was deleted from all but the cotton equation because of statistical insignificance The wage index may be collinear with the real price of crude petroleum because Canada is a major energy producer

Econometric Estimates

Table 1 shows the SUR and OLS estimates for the Canadian demands for U S supplies of cotton, rice, and soybeans Evidence is insufficient at the 95-percent confidence level to suggest serial correlation

I included the real crude petroleum price (RLPET) for two reasons First, the large geographic area covered by the United States and Canada means that transportation and related costs significantly influence the cost of crop imports Second, RLPET may generate a positive sign, as with the rice and soybean equations, because Canada is a major energy producer Previous research has employed a real petroleum price variable as a proxy for a region's real income trends (*2*, p 15) The cotton relation excludes RLPET because sample evidence suggests collinearity with the real price of polyester, a petroleum-based substance

Efficiency and Improved Inference

Estimating seemingly unrelated equations with OLS ignores contemporaneous correlation and generates inefficient estimates Estimating these relations with SUR uses such correlations and generates efficient estimates (*7, 8*)

Inference parameters for the coefficient estimates are improved through increased efficiency Smaller standard errors imply more precise confidence intervals for coefficient estimates and for the trade parameter estimates that certain coefficients imply Also, increased efficiency through SUR translates into t-values altered from OLS-generated levels, providing clearer indications of the relationships between regressors and the dependent variable

Table 2 shows the estimated standard errors for SUR- and OLS-generated regression estimates associated with Canadian import demands Choosing SUR over OLS resulted in evidence that strongly suggests efficiency gains SUR-estimated standard errors declined from OLS-generated levels for each coefficient in all three equations, as econometric theory would suggest (*8*, pp 517-25) Yet, the degree of such gains, and their degree of improved inference reliability, is a study-specific gain which is very important to researchers of U S -Canadian agricultural trade Table 2's SUR-generated estimates in standard errors declined from

Table 1—Econometric estimates of Canadian imports of U.S. crops

Variable	Explanation	SUR	OLS
UCTNC	Canadian imports, U S cotton		
INT	Intercept	−134 141	−125 677
t-value		−1 617	−1 064
WGIXCN	Index of Canadian hourly wages	26 053	28 987
t-value		2 002	1 567
PSOYCN	Price, U S soybeans, deflated Canadian dollars	1 341	1 793
t-value		1 993	1 830
X7172	Indicator variable	167 689	174 914
t value		5 602	3 446
PPLYCN	Price, polyester, deflated Canadian dollars/lb	240 555	248 162
t value		3 998	2 859
PCTCN	Price, U S cotton, deflated Canadian dollars/bale	− 202	− 556
t-value		− 347	− 606
PRICN	Price, U S rice, deflated Canadian dollars	265	136
t-value		926	333
R-square		623	633
d	Durbin-Watson	2 658	2 733
t(residual)	t-value, coefficient on lagged residuals[1]	− 800	− 800
URICN	Canadian imports, U S rice		
INT	Intercept	22 810	21 316
t-value		4 528	3 368
PRICN	Price, U S rice, deflated Canadian dollars	− 047	− 042
t-value		−3 046	−1 943
PCTCN	Price, U S cotton, deflated Canadian dollars	015	022
t value		505	512
TIME	Time trend	2 158	2 144
t-value		6 352	5 118
RLPET	Real price, crude petroleum	2 414	2 309
t-value		5 585	4 215
X78	Indicator variable	6 306	7 649
t-value		3 030	2 316
R-square		984	985
d	Durbin-Watson	2 001	2 027
USYCN	Canadian imports, U S soybeans		
INT	Intercept	618 639	604 348
t-value		7 746	5 681
PSOYCN	Price, U S soybeans, deflated Canadian dollars	− 969	−1 098
t-value		−2 671	−2 323
RLPET	Real price, crude petroleum	19 936	17 638
t value		2 887	1 952
PWTCDA	Price, Canadian wheat, deflated Canadian dollars	161	385
t-value		252	392
TIME	Time trend	−15 312	−13 548
t-value		−2 776	−1 898
R-square		563	564
d	Durbin Watson	2 380	2 405
t(residual)	t-value, coefficient on lagged residuals	− 887	− 887

[1]The cotton and soybean equations generated Durbin-Watson values well into the inconclusive range For each of these two equations, I used OLS and regressed the OLS residuals against the one period lag of the residuals, and reported the coefficient's t value, t(residual) (see *6, 7*) Both t(residual) values suggest that evidence is insufficient at the 95 percent confidence level to reject the null hypothesis of a zero coefficient I did not include the rice equation's t(residual) because it was nearly zero The Durbin Watson value fell just barely in the inconclusive range's upper end

OLS levels by no less than 18 9 percent in all instances, by at least 20 percent in all but one instance, and by more than 29 percent in 11 of the 18 instances Analysts involved in analyzing the North American Accord's consequences should therefore not ignore contemporaneous correlation characterizing U S - Canadian models of agricultural trade

SUR/OLS Differences: Trade Elasticity Estimates

Table 3 shows estimated values of own-price elasticities of Canadian demand for U S cotton, rice, and soybeans (hereafter, the Canadian price elasticities) Comparable estimates from previous research were not located

Table 2—SUR/OLS differences in standard error estimates[1]

Equation/ variable	Explanation	Difference SUR compared with OLS
		Percent
Cotton		
INT	Intercept	−29 8
WGIXCN	Index, Canadian hourly wages	−29 7
PSOYCN	Price, U S soybeans	−31 3
X7172	Indicator variable	−41 0
PPLYCN	Polyester price	−30 7
PCTCN	Price, U S cotton	−36 6
PRICN	Price, U S rice	−30 2
Rice		
INT	Intercept	−20 4
PRICN	Price, U S rice	−29 6
PCTCN	Price, U S cotton	−29 4
TIME	Time trend	−18 9
RLPET	Price, crude oil	−21 1
X78	Indicator variable	−37 0
Soybeans		
INT	Intercept	−24 9
PSOYCN	Price, U S soybeans	−23 2
RLPET	Price, crude oil	−23 6
PWTCDA	Price, Canadian wheat	−34 9
TIME	Time trend	−22 7

[1]Variables are defined in the text and table 1

Table 3—Own-price elasticities of Canadian demands for U S crops

Crop	Elasticities		Differences in absolute values
	SUR-estimated model	OLS-estimated model	
			Percent
Cotton	−0 121	−0 332	−63 6
Rice	− 162	− 146	11 0
Soybeans	− 334	− 378	−11 6

SUR/OLS differences in the Canadian price elasticities fall within the 11-12 percent range for the rice and soybean relations and exceed 63 percent for the cotton equation This article's SUR and OLS point estimates vary for each coefficient and therefore for implied trade parameters (*2*) Policy decisions are based on such point estimates, which vary across even unbiased estimators, and are not based on the unknown expected values, which are equal across unbiased estimators Accounting for Canada's cross-crop contemporaneous correlation emerges as an important concern for researchers who analyze U S / Canadian trade in farm products For example, a proposed policy's cotton price reduction would imply a far smaller predicted effect on Canadian cotton demand should the analyst use the SUR-generated own-price elasticity of −0 121 rather than the OLS generated estimate of −0 332 (table 3) One expects unbiased SUR and OLS estimates of the coefficients and resulting trade parameters (*6, 7, 8*) One may not necessarily expect, however, that correcting for the model's cross-crop contemporaneous correlation generates differences of more than 60 percent in the policy-relevant point-estimates of Canada's own-price elasticities for a crop

When confronted with seemingly unrelated Canadian demands for U S crops, analysts should de-emphasize the equality of unknown expected values of a particular coefficient's unbiased SUR and OLS estimates Analysts should rather stress how the coefficient's point-estimates differ across the two unbiased estimators

Forecast Accuracy Beyond the Sample

I calculated the annual forecast errors and mean absolute percentage errors (MAPE's) for 1983-85 (the validation period), 3 years beyond the sample period By following a recent study's procedure (*2*, pp 18-19), I provide the naive model's forecasts for comparison because comparable validation results were not located A naive prediction is the prior period's observed value Table 4 provides the information on forecast performances

Note that the 1983-85 validation period spanned a time of great uncertainty concerning the provisions of the then-imminent Food Security Act of 1985 (*2, 3*) This uncertainty may explain the rather large MAPE's for the estimated and naive models Both versions of the estimated equations predicted more accurately than the naive model in two of the three cases

Recall that SUR and OLS estimators of seemingly unrelated equations are unbiased, generating coefficient estimates with equal expected values (*2, 7, 8*)

Yet, forecasts are not made with the unknown expected coefficient values but with the coefficient point estimates, which clearly vary across even unbiased estimators (see table 1) SUR point estimates vary from OLS levels in a manner that improves the Canadian model's overall forecast accuracy in two ways First, table 4 illustrates that accounting for Canada's cross-crop contemporaneous correlation results in a higher or worse MAPE in only one of the three modeled markets The SUR-generated MAPE's were as good as, or better than, OLS-generated levels in two markets Second, the SUR-generated annual forecast errors were less than OLS errors for every year, or nearly every year, for equations whose SUR MAPE's are equal to or less than the OLS MAPE's

The results suggest that correcting for Canada's cross-market contemporaneous correlation provides forecast performances as good as, or superior to, performances of the OLS model in most markets

Conclusions

Sample evidence suggests that the own-price elasticities of Canadian demands for cotton, rice, and soybeans are highly inelastic (see table 3) Accounting for the model's contemporaneous correlation resulted in declines from OLS levels in the standard error estimates of each coefficient, as expected from econometric theory, and enhanced the reliability and precision of policy-pertinent inference parameters The large degree of these gains, however, is study-specific (see table 2) Researchers and policymakers should note the contemporaneous correlation's large distortions of inference parameters that are relevant to U S -Canadian trade in farm products Correcting for the Canadian import model's contemporaneously correlated disturbances with SUR-generated large differences from OLS levels in the point estimates of coefficients and in certain trade parameters The SUR version, which corrected for Canada's cross-market contemporaneous correlation, predicted as accurately as, or more accurately than, the OLS version, which ignored the problem, even though both versions' estimates were unbiased Analysts should rely less on the property of equal but unknown expected values and should stress how greatly the policy-pertinent point estimates differ across unbiased estimators SUR should be used, and OLS avoided, when estimating this article's seemingly unrelated equations of U S /Canadian crop flows, even though both techniques are unbiased Correcting for contemporaneous correlation greatly influenced both the size of the policy-relevant trade parameter estimates and the forecasts of Canadian purchases of U S crops

Table 4—Forecast errors and mean absolute percentage errors (MAPE's) of forecasts, 1983-85

Crop/version	1983	1984	1985	MAPE
		Percent		
Cotton				
SUR	−18 7	−10 2	7 1	12 0
OLS	−14 6	−5 4	11 4	10 5
Naive	−26 0	4 5	37 0	22 5
Rice				
SUR	−12 5	−11 9	41 4	21 9
OLS	−12 6	−12 0	41 2	21 9
Naive	−8 7	0	59 7	22 8
Soybeans				
SUR	16 7	22 4	59 7	32 9
OLS	19 0	25 6	66 7	37 1
Naive	48 1	13 9	33 0	31 7

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