Canada's Broiler Supply Management Program: A Shield From U.S. Price Volatility?

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Abstract. *Canadian broiler price responses to increases in U S prices either have lessened in magnitude and duration or have been eliminated since Canada's broiler supply management program began in 1979 The authors used monthly vector autoregressions of U S and Canadian broiler prices (farm and retail), estimated for periods before and after Canada introduced its broiler supply management program, to arrive at the results The analysis also demonstrated that data-oriented, time-series statistical methods are useful in policy analysis when focusing on a policy's dynamic aspects, contrary to the opinion of some researchers*

Keywords. *Canadian broiler supply management, corn and broiler prices, vector autoregression, dynamic price transmissions*

Canada implemented a national broiler supply management program (hereafter, the Canadian NSM program) in 1979 to augment its existing provincial programs and to insulate Canadian broiler prices from U S broiler price fluctuations

Since the U S /Canadian free trade agreement (FTA) in 1989, the methods and the success of the Canadian broiler program have been scrutinized from both sides Policymakers involved with the FTA need to know how, and to what extent, Canada's broiler program has impeded U S /Canadian broiler price signals, and hence broiler trade, even though the FTA exempts broilers This information is important because (1) the FTA aims eventually to liberalize agricultural trade generally, (2) the FTA recently instituted a modest liberalization (increase) in the Canadian broiler import quota, and (3) Canadians and Americans, already in a "trade-liberalizing" frame of mind, may further liberalize U S /Canadian broiler trade again in the future (see *7*, *8*, *9*) [1] Any future liberalization of this broiler trade requires quantifying the price signal impediments of such existing policy barriers as the Canadian NSM program Further, an understanding of how the existing Canadian NSM program has succeeded in blocking U S /Canadian cross-border broiler price interchange would provide useful information for analysts in other nations that are considering similar policies

This paper focuses on whether, and to what degree, Canadian broiler supply measures have succeeded in blocking out American broiler price influences on Canadian broiler prices Vector autoregression (VAR) techniques are used to glean empirical regularities from monthly data on four broiler prices converted to deflated Canadian dollars U S farm price (USFP), U S retail price (USRP), Canadian farm price (CFP), and Canadian retail price (CRP) Monthly VAR models of the price transmission mechanism are estimated for an early period before (January 1967-December 1978), and for a recent period after (January 1980-December 1987), introduction of national supply management (the early and recent models, respectively) By comparing the early and recent models' dynamic characteristics of U S /Canadian broiler price transmissions, we discern how such dynamic price transmissions and cross-border price relationships have changed since the the 1979 implementation of Canada's NSM program

Estimated VAR Model, Data Sources, and Scenario Design

The literature is replete with summaries of VAR econometrics, so another such summary is not presented here For background information on VAR econometrics, see Sims (*21*) and Bessler (*5*)

The following VAR model was estimated for the early and recent periods

$$\begin{aligned} USFP_t = {} & a_{UF,0} + a_{UF,T}*TRD + a_{UF,1}*USFP_{t-1} \\ & + a_{UF,k}*USFP_{t-k} + a_{UF\,k+1}*USRP_{t-1} \\ & + a_{UF,2k}*USRP_{t-k} + a_{UF\,2k+1}*CFP_{t-1} \\ & + a_{UF,3k}*CFP_{t-k} + a_{UF\,3k+1}*CRP_{t-1} \\ & + a_{UF\,4k}*CRP_{t-k} + A_t \end{aligned} \quad (1)$$

$$\begin{aligned} USRP_t = {} & a_{UR,0} + a_{UR\,T}*TRD + a_{UR\,1}*USFP_{t-1} \\ & + a_{UR\,k}*USFP_{t-k} + a_{UR\,k+1}*USRP_{t-1} \\ & + a_{UR,2k}*USRP_{t-k} + a_{UR\,2k+1}*CFP_{t-1} \\ & + a_{UR,3k}*CFP_{t-k} + a_{UR\,3k+1}*CRP_{t-1} \\ & + a_{UR,4k}*CRP_{t-k} + B_t \end{aligned} \quad (2)$$

$$\begin{aligned} CFP_t = {} & a_{CF\,0} + a_{CF,T}*TRD + a_{CF\,1}*USFP_{t-1} \\ & + a_{CF\,k}*USFP_{t-k} + a_{CF,k+1}*USRP_{t-1} \end{aligned} \quad (3)$$

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

$$+ \quad + a_{CF,2k}*USRP_{t-k} + a_{CF,2k+1}*CFP_{t-1}$$

$$+ \quad + a_{CF\ 3k}*CFP_{t-k} + a_{CF,3k+1}*CRP_{t-1}$$

$$+ \quad + a_{CF,4k}*CRP_{t-k} + C_t$$

$$CRP_t = a_{CR\ 0} + a_{CR\ T}*TRD + a_{CR\ 1}*USFP_{t-1} \qquad (4)$$

$$+ \quad + a_{CR,k}*USFP_{t-k} + a_{CR,k+1}*USRP_{t-1}$$

$$+ \quad + a_{CR\ 2k}*USRP_{t-k} + a_{CR\ 2k+1}*CFP_{t-1}$$

$$+ \quad + a_{CR\ 3k}*CFP_{t-k} + a_{CR\ 3k+1}*CRP_{t-1}$$

$$+ \quad + a_{CR,4k}*CRP_{t-k} + D_t$$

The variables USFP, USRP, CFP, and CRP are defined above The a-coefficients are regression coefficient estimates The a-subscripts have the following broiler price designations UF for U S farm price, UR for U S retail price, CF for Canadian farm price, and CR for Canadian retail price TRD is a time trend The a-coefficient with an upper case "T" subscript is the coefficient estimate on the time trend The a-coefficients with a zero denote the intercept estimates The A_t, B_t, C_t, and D_t denote the error terms or innovations of the USFP, USRP, CFP, and CRP equations, respectively Eleven indicator variables account for seasonal effects Data are in natural logarithms, and k refers to the number of lags

Statistics Canada provided the Canadian farm price (CFP) of broiler chickens and the Canadian retail price index (CRP) for broilers The U S Bureau of Labor Statistics provided the U S prices producer price index ("farm products" index group) for broilers and fryers as the USFP and the consumer price index ("all-urban consumers" index group) for fresh whole chicken, as the USRP All prices were converted to deflated Canadian dollars Data were modeled in natural logarithms, such that shocks to and impulse responses in the logged prices represent proportional changes in the nonlogged prices When multiplied by 100, the impulse responses reflect percentage changes in the nonlogged prices

Data for all four prices were obtained from January 1966 (1966 1) Twelve observations were removed from each period's onset for use in the Tiao and Box likelihood ratio test procedure for lag selection (*23*) These results (not reported here) suggest, at Lutkepohl's suggested significance level of 1 percent, six lags for the early model and nine lags for the recent model

For both models, each equation's Ljung-Box Q statistic, distributed as a chi-square variable, tested the null hypothesis that the equation was properly specified to render white noise residuals (*16*, p 99) One rejects the null hypothesis when an equation's Q-value exceeds the critical value Assuming a 1-percent significance level, the critical chi-square value is 58 6 with 36 degrees of freedom for the early model and 47 with 27 degrees of freedom for the recent model Evidence was insufficient to reject the null hypothesis of model adequacy for all eight equations in both models The early model's Q-values ranged from 27 5 to 34 5, while those of the recent model ranged from 15 5 to 23 6

Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests were performed on the residuals of each of the four equations in each model Dickey and Fuller (*11, 12*) developed a stationarity test by regressing a variable's (here a VAR equation's residuals') first differences against a one-period lag of the variable's nondifferenced levels and a constant Engle and Granger (*14*) and Hall (*17*) employed an ADF test In addition to the DF test's regressors, the ADF test regressors include a number of lagged dependent variables (here, lags of the differenced residuals) Hsiao's (*18*) method of lag selection based on Akaike's final prediction error criterion determined the number of lagged dependent variables in each test With the DF and ADF tests, the null hypothesis of a nonstationary series is rejected when the t-like value on the nondifferenced lagged regressor is negative and exceeds about 3 5 in absolute value (*11, 12, 15, 17*) For the early model, pseudo-t values ranged from –11 5 to –12 4 for the DF tests, and from –7 5 to –8 3 for the ADF tests For the recent model, the pseudo-t values ranged from –8 4 to –12 01 for the DF tests, and from –5 9 to –6 9 for the ADF tests So evidence was sufficient in all cases to reject the null hypothesis of nonstationary residuals, and this suggests stationarity of both modeled VAR's

The analytical procedure involved several phases First, the VAR's in equations 1 through 4 were estimated for the early and recent periods with ordinary least squares, a procedure that Bessler (*5, 6*) noted as appropriate

Second, two experiments were performed on each model Each model was shocked with a one-time increase in U S farm price, and the CFP and CRP responses were observed Then, each model was shocked with a one-time rise in U S retail broiler price, and the responses in the two Canadian broiler prices were examined Kloek and Van Dijk's Monte Carlo methods were employed and provided a t-value to test the null hypothesis that each impulse is zero (see *1*)

Third, decompositions of forecast error variance (FEV) were calculated, analyzed, and compared for each model to determine how the four prices were interrelated in each period This study follows Sims (*21*) and employs Chow's method to test for coefficient constancy ("structural change") on each of the model's equations The Chow test results suggest whether the modeled prices have experienced statistically signifi-

cant change between the two periods, and show where in the VAR's such change has occurred (*22*)

Dynamic information on Canadian broiler price responses from U S price shocks for the recent and early models include reaction times, directions and patterns, and durations of statistically nonzero impulses of Canadian broiler prices Also, results permitted a comparison of Canadian impulse responses across Canada's farm and retail sectors, as well as how such response patterns today resemble, or differ from, those experienced before the 1979 implementation of national broiler supply measures [2] We learned how the interrelationships among American and Canadian broiler prices have changed since the 1979 Canadian program was implemented

Influences of U.S. Broiler Price Shocks on Canadian Broiler Prices

The impulse response function simulates, over time, the effect of a one-time shock in one of a VAR's series on itself and on other series in the system (*5*) Each model was shocked with a one-time increase in USFP and then in USRP Canadian impulse responses in farm and retail broiler prices were then comparatively analyzed across the Canadian farm and retail sectors, and then across time (early, recent periods)

Following standard procedure, a shock equaled the absolute value of the standard error of the shock variable's historical innovation, hereafter denoted the variable's standard error (*5, 25*) These shocks constitute 7 5-percent and 4 2-percent increases in the early period's American farm and retail broiler prices, respectively, and 5 8 percent and 2 3 percent for the recent period's USFP and USRP, respectively

A Choleski decomposition was imposed on each VAR to orthogonalize the current innovation matrix, such that the variance/covariance matrix of each model's innovations is identity The series were ordered as USFP to USRP to CFP to CRP For both countries, this paper follows previous research and places farm price ahead of retail price because this is the observed chronological ordering of such pricing points in the food and fiber chain (*3, 4*) Such an ordering is further in line with such standard agricultural price texts as Tomek and Robinson (*24*) U S broiler prices were placed ahead of the two Canadian prices because of the Canadians' past perceptions that influences ran from U S to Canadian broiler prices—perceptions that partly led to the Canadian broiler supply measures

Figure 1 shows the impulse *responses* (not levels) in Canadian broiler price to U S broiler price shocks for the early model Figure 2 shows Canadian broiler price responses to American broiler price increases for the recent period after the implementation of the national supply management program Circled impulses denote Canadian broiler price impulses that are statistically different from zero at the 5-percent significance level We emphasize the statistically nonzero impulses

Panels 1a and 2a provide Canadian farm price responses to a rise in U S farm price for the early and recent models, respectively Before national broiler supply management, a rise in U S farm price was followed by immediate and statistically significant increases that peaked in month 4, and that endured for 6 months Today, CFP responds to a USFP increase in a delayed manner, and endures for just 1 month

Panels 1b and 2b provide Canadian retail price responses from an American farm price increase Before national supply management, Canadian retail responses to a USFP shock were immediate, accelerated in power through the month-4 peak, and lasted with significance for 10 months Today, USFP shocks seem to have a far less enduring impact on CRP, which now responds for only 6 months, during which most (five) impulses are significant

Panels 1c and 2c provide Canadian farm price impulses from a USRP increase for the early and recent models, respectively Prior to national supply management, CFP responses were immediate, accelerated in strength through a month-6 peak, and endured for 8 months Today, the USRP/CFP link has been virtually wiped out, with evidence insufficient to suggest that any of panel 2c's CFP-responses were nonzero

Panels 1d and 2d show Canadian retail price responses triggered by a rise in American retail price for both models Before the 1979 national supply management program, CRP rose in a largely significant pattern for 9 months Since 1979, CRP responses are almost all statistically zero and virtually without direction

The four comparisons in the two figures indicate the

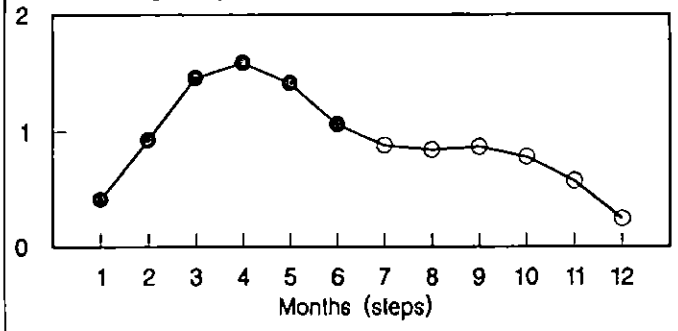
[2]We would have preferred to analyze the dynamic consequences on U S/Canadian broiler price transmissions of both Canada's national and (assorted) provincial supply programs Three models would have been required (a) one estimated over a period before the provincial and national measures, (b) one estimated over a period after implementation of the provincial measures but before the national measures and (c) one estimated over a period following implementation of both Canada's provincial and national measures Comparison of models (a) and (b) would investigate the dynamic impacts on U S /Canadian broiler price transmissions of provincial measures, and comparing models (b) and (c) would investigate the influence of the Canadian NSM program Comparing models (a) and (c) would furnish the dynamic impacts of both the Canadian provincial and national measures Data were not historically plentiful enough to estimate model (a) with adequate degrees of freedom, precluding the comparisons of models (a) and (b) and models (a) and (c) So, we concentrated on estimating early VAR model (b) over the 1967 1-78 12 period and the recent model (c) over the 1980 1-87 12 period These two models offered a comparison of the U S /Canadian broiler price transmissions before and after the Canadian NSM program, whereby both periods fell within the regime after implementation of the provincial programs We cut the recent model's estimation off at 1987 12 to prevent possible preliminary influences of what was thought by many in 1988 to be an imminent FTA (*7*)

Figure 1

Canadian Broiler Price Impulses, PD 1

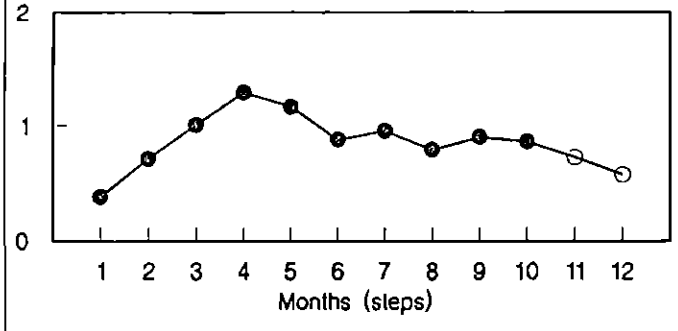
Panel 1a Canadian farm broiler price impulses from a shock in US farm price Early period

Percent change in price



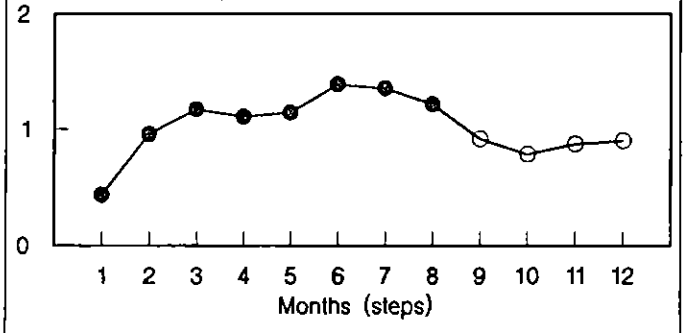
Panel 1b Canadian retail broiler price impulses from a shock in US farm price Early period

Percent change in price



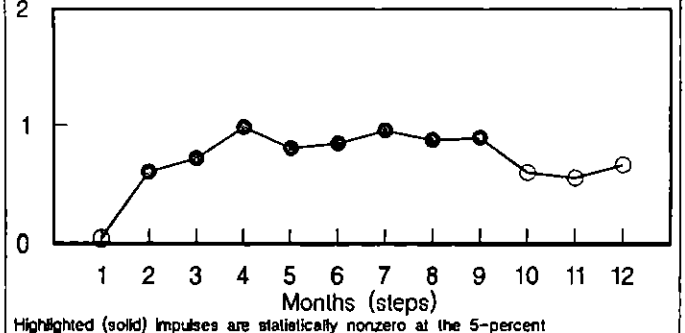
Panel 1c Canadian farm broiler price impulses from a shock in US retail price Early period

Percent change in price



Panel 1d Canadian retail broiler price impulses from a shock in US retail price Early period

Percent change in price



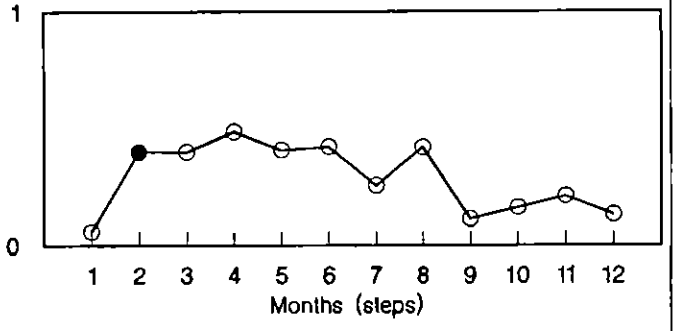
Highlighted (solid) impulses are statistically nonzero at the 5-percent significance level.

Figure 2

Canadian Broiler Price Impulses, PD 2

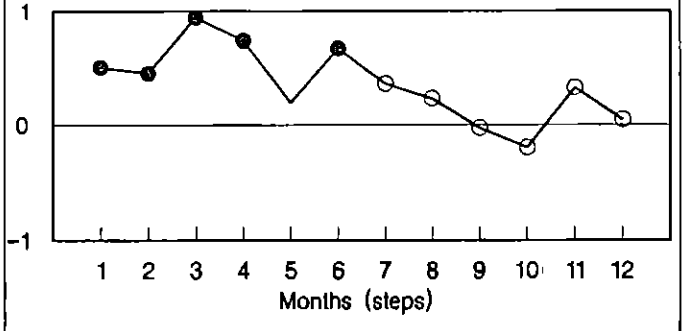
Panel 2a Canadian farm broiler price impulses from a shock in US farm price Recent period

Percent change in price



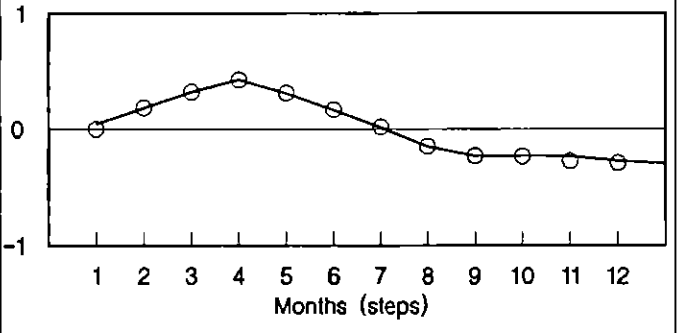
Panel 2b Canadian retail broiler price impulses from a shock in US farm price Recent period

Percent change in price



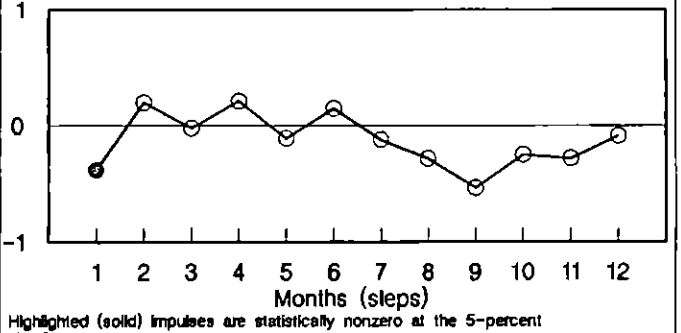
Panel 2c Canadian farm broiler price impulses from a shock in US retail price Recent period

Percent change in price



Panel 2d Canadian retail broiler price impulses from a shock in US retail price Recent period

Percent change in price



Highlighted (solid) impulses are statistically nonzero at the 5-percent significance level.

successes and failures of Canada's NSM in insulating Canadian broiler prices from U S broiler price movements The figures furnish early/recent model comparisons of the dynamic price transmission for the following four U S /Canadian broiler price linkages USFP/CFP in the a-panels, USFP/CRP in the b-panels, USRP/CFP in the c-panels, and USRP/CRP in the d-panels

The Canadian NSM program was largely successful in blocking these four price linkages The early-model panels in figure 1 clearly indicate that the four linkages were conduits of cross-border price transmissions of noticeable strengths and durations before the 1979 implementation of Canada's NSM program Yet figure 2's panels show that after 1979, three of the four linkages were blocked (or nearly so) USFP/CFP, USRP/CFP, and USRP/CRP And further, the one linkage (USFP/CRP) that managed to endure after 1979 was noticeably weakened

On the other hand, while largely successful, the Canadian NSM program has not completely blocked these four price linkages and their U S /Canadian broiler price transmissions Panels 1b and 2b suggest cross-border price impulses at the Canadian retail level The data-oriented and nonstructural methods used here have imposed a minimum of theoretical restrictions on the data to discern these pre- and post-1979 price transmission dynamics As Bessler (*5*) has noted, the methods are designed to indicate what pre-1979 dynamics existed and what post-1979 dynamics still exist, but say little concerning the cause of the dynamics in each of these two periods Our methods cannot reveal why, for example, the remaining cross-border broiler price transmissions are focused primarily on Canadian retail prices Such issues are for more theoretically based and market-oriented models and analyses Bessler (*5*) noted, however, that dynamic results such as ours set the stage for, and constitute the first stage of, such theoretical and market-oriented inquiry

Decompositions of Forecast Error Variance

Analysis of decompositions of forecast error variance (FEV) identifies the interrelationships among a modeled system's time series (*21*) Error decompositions attribute within-sample error variance to alternative series and thus give a measure useful in applied work (*5*) FEV decompositions for k-step ahead forecasts were calculated for early and recent models (table 1) (Note that FEV decompositions for USFP and USRP were not of direct relevance to this inquiry and were eliminated to conserve space) A variable is considered largely exogenous/endogenous when large/small portions of its FEV are attributed to own-variation (*5*) In the recent period since implementation of national broiler supply management, Canadian farm broiler price is largely exogenous at most reported horizons (30 months or less) because more than half of the FEV is self-explained CRP contributes substantially to CFP's FEV at most horizons

Since the supply management program began, both U S (farm and retail) prices have contributed less toward the explanation of the CFP's FEV than previously at most horizons This coincides with the dampened Canadian price responses elicited by American broiler price shocks since the early period

Since 1979, Canadian retail price has been highly exogenous, with more than half of its FEV self-attributed at most reported horizons Canadian farm price is the second largest contributor to CRP's FEV at all reported horizons

Canadian retail price relationships to other modeled broiler prices have changed in several ways since 1979 CRP has become more exogenous CFP contributes less toward the explanation of CRP's FEV than formerly at most horizons Also, USRP now contributes less toward explaining the CRP's FEV than formerly at all horizons This lessened USRP contribution to Canadian retail price's uncertainty reinforces the lessened CRP impulse responses elicited by American price shocks

Formal Evidence of Structural Change

"Structural change" denotes a situation when statistical evidence suggests (here, at the 5-percent significance level) that regression coefficients have changed between the early and recent periods Following Sims (*21*), this study used the Chow test on each of the four price relations to test whether coefficients have changed since the period before January 1979 Due to space considerations, this study does not summarize the actual test We refer the reader to Shrader, Bessler, and Preston for specifics on this test (*22*)

One rejects the null hypothesis that an equation's coefficients are constant over the two periods when the full vs reduced F-value exceeds the tabular value (1 44 with 37, 166 degrees of freedom) Of the four F-tests, evidence was insufficient to suggest structural change in the USFP, USRP, and CFP equations With a 1 54 F-value, evidence was sufficient to suggest structural change in the CRP or Canadian retail broiler price equation Perhaps this evidence of change arises, in part, from the enhanced degree of CRP exogeneity in the recent period (table 1)

Findings and Conclusions

Evidence suggests that today's U S broiler price movements are followed by smaller and less enduring responses in Canadian broiler prices than during the period preceding Canada's national broiler supply

Table 1—Proportions of forecast error variance of Canadian broiler prices, k months ahead, allocated to innovations in U.S. and Canadian broiler prices

Price and k (months ahead)	Standard error	U S farm price	U S retail price	Canadian farm price	Canadian retail price
			Percent		
Model for early period. 1967·1—1978:12					
Canadian farm price					
1	0 03012	11 48	12 23	76 28	0
6	06636	21 93	20 02	55 75	2 31
12	08867	15 44	17 88	62 99	3 68
18	09971	13 13	17 19	66 56	3 12
24	10677	12 54	20 04	64 69	2 73
30	11122	11 65	24 00	61 75	2 60
36	11304	11 28	25 80	60 33	2 59
47	11347	11 34	26 07	59 97	2 62
48	11350	11 35	26 05	59 97	2 62
Canadian retail price					
1	02414	11 34	6 24	11 77	70 66
6	05221	23 45	15 19	24 11	37 25
12	07006	19 42	14 56	40 57	25 45
18	07959	15 41	13 45	51 25	19 90
24	08570	14 70	15 00	53 13	17 17
30	08976	13 70	19 08	51 49	15 72
36	09195	13 07	21 83	49 99	15 11
47	09257	12 99	22 54	49 52	14 95
48	09259	13 01	22 53	49 51	14 95
Model for recent period. 1980:1—1987:12					
Candian farm price					
1	01794	5 20	1 13	93 62	06
6	03354	8 81	3 99	86 80	40
12	03720	7 93	5 69	84 05	2 33
18	04130	10 67	6 44	68 89	14 00
24	04706	14 29	5 24	55 39	25 07
30	04843	16 37	5 51	52 57	25 55
36	05440	13 05	7 75	43 69	35 51
47	06442	9 51	11 28	33 51	45 69
48	06446	9 50	11 35	33 47	45 67
Canadian retail price					
1	02222	9 16	3 78	16 36	70 69
6	03443	21 02	2 36	28 10	48 52
12	03936	17 45	5 52	28 93	48 10
18	04302	15 73	5 30	26 46	52 51
24	04992	13 31	5 96	21 70	59 03
30	05130	13 30	6 27	20 72	59 71
36	05330	12 41	6 59	20 04	60 96
47	05805	10 59	8 90	17 65	62 85
48	05807	10 59	8 94	17 64	62 82

management program Since the early period, the Canadian price responses to a USFP shock are more delayed and far less enduring (1 month instead of 6) at the farm level, and endure only 6 months (instead of 10) at the retail level In a statistical sense, the Canadian farm and retail broiler price responses to USRP shocks appear to have been eliminated since the early period

Generally, results of the impulse responses, FEV decompositions, and Chow tests all point to change at Canadian retail price level Results suggest that (1) American broiler price fluctuations influence the recent model's CRP less than the early model's CRP, (2) the FEV decompositions imply that the recent model CRP is more exogenous and less dependent on the Canadian farm price than in the early model, and (3) structural change has occurred at the CRP level These results fail to contradict the evidence uncovered by Coffin, Romain, and Douglas (*10*) that the Canadian food retail industry is becoming more concentrated in a few, large firms, with more market power at both the provincial and national levels But, we conjecture that the Canadian food retail industry may have been changing and becoming less competitive in nature, such that CRP is more dependent on its own past levels than on other related prices in the neoclassical competitive production model But, this is only conjecture,

as our nonstructural statistical methods do not offer insight concerning such explanations

The Canadian NSM program has been largely successful in blocking the price transmissions through the four examined U S /Canadian broiler price linkages Since the program's 1979 implementation, three have been blocked or nearly blocked The one remaining linkage conducts cross-border price transmissions that are weaker and only about half as enduring as the same transmissions before the Canadian NSM program's implementation

These results are useful to policy analysts charged with liberalizing the U S /Canadian agricultural trade, or to other analysts interested in adapting policies similar to Canada's NSM program Canadians must know the cross-market consequences on their broiler prices of a grain-related liberalization which would influence the price of U S feed and, in turn, of U S broilers Canadians and Americans should know the degrees to which existing broiler and nonbroiler agricultural programs directly or indirectly impede Canadian/U S trade in broiler products

Another result is a methodological one We have shown that useful policy analysis is possible using the data-oriented time series techniques of vector autoregression Policy analysis that involves such dynamic aspects of price transmissions as the following can be successfully addressed using these techniques price response reaction times, response directions and patterns, and response durations As Bessler (*5*, *6*) notes, these dynamics are often not adequately addressed by more conventional structural econometric models, or by the static theory underlying such models These structural models use static theory, modeling well what happens at pre- and post-shock equilibria We, however, have modeled what dynamically happens to selected variables between the pre- and post-shock equilibria In so doing, we have shown that the nontheoretical and nonstructural VAR methods can effectively analyze policies that involve the dynamic characteristics of the examined price transmissions

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