Modeling Frozen Beef Purchases

Like fresh beef purchases, the variation in weekly frozen beef purchases is large and can mostly be explained by accounting for trend and seasonality. We account for the increasing seasonal variation through a natural logarithm transformation of the weekly purchase series. Afterward, trend and seasonality explain 71 percent of the variation in (log transformed) purchases. We account for the long-term trend in purchases estimating the model

$$\ln y_t = C + \alpha t + \varepsilon_t \quad t = 1, 2, ..., 364$$

where $\ln y_t$ is (log transformed) pounds of frozen beef purchased in week t, C is a constant, t is a time index, and the error is assumed zero mean with constant variance.[5] Figure 3 suggests that the variability of weekly purchases increased over time. We used the logarithm of purchases as our dependent variable rather than the level of purchases because tests for homoscedasticity rejected the assumption of constant variance in levels, but not in logs.

Results are in the left-most numerical column in table 4. By itself, the trend explains 11 percent of the variation (R^2) in quantity purchased. Seasonality is accounted for by regressing weekly quantities purchased on 52 seasonal 0/1 (dummy) variables, as well as on the time trend. The effects of trend and seasonality are captured by the model

$$\ln y_t = \alpha t + \sum_{i=1}^{52} \gamma_i D_{it} + \varepsilon_t \quad t = 1, 2, ..., 364$$

The middle numerical column of table 4 shows results of this estimation. Again, the time trend is significant, as are all 52 seasonal dummy variables. Together the trend and seasonal variables explain 71 percent of the variation in (log transformed) weekly quantity purchased.

The explanatory power of the estimated model is large enough that the model could be used to provide evidence for the existence of a wide class of possible impacts of the BSE announcements. Our third model is intended to identify impacts of the BSE announcements. As with fresh beef, we define five new dummy variables to indicate the weeks immediately following the Canadian announcement and five dummy variables to indicate weeks immediately following the Washington State announcement.

The model accounting for trend, seasonality, and the BSE announcements is

$$\ln y_t = \alpha t + \sum_{i=1}^{52} \gamma_i D_{it} + \sum_{j=1}^{5} \delta_j CAN_{jt} + \sum_{k=1}^{5} \delta_k WASH_{kt} + \varepsilon_t \quad t = 1, 2, ..., 364$$

Results are in the right-most column of table 4. Although estimated coefficients on the first three weekly dummy variables are negative (indicating reduced purchases), none of the five variables representing the weeks

[5] Unlike the fresh beef trend, a quadratic term did not meet conventional tests of significance and was not added to regression equations for frozen beef.

Table 4
Regression results from trend; trend and seasonal model; and trend, seasonal, and BSE announcement model

Independent variables	Time trend model	Time trend and seasonal model	Time trend, seasonal, and BSE announcement model
	Dependent variable: Quantity purchased frozen beef		
	Estimated coefficient (p value)		
Constant	14.98449 (0.0000)		
Time trend	0.001468 (0.0000)	0.001565 (0.0000)	0.001614 (0.0000)
52 seasonal dummy variables		All highly significant	All highly significant*
CAN1			-0.022661 (0.9390)
CAN2			-0.178461 (0.5471)
CAN3			-0.307324 (0.3000)
CAN4			0.021930 (0.9410)
CAN5			-0.268271 (0.3655)
WASH1			-0.547789 (0.0658)
WASH2			-0.228832 (0.4411)
WASH3			0.284611 (0.3381)
WASH4			-0.142814 (0.6306)
WASH5			-0.101990 (0.7312)
Summary statistics			
R^2	0.108821	0.709733	0.716762
Adjusted R^2	0.106359	0.661200	0.658421
Durbin-Watson	0.790331	1.989305	1.997355

Source: Economic Research Service/USDA.

following the Canadian announcement are significant. That is, there is no compelling evidence to suggest the announcement led purchases away from the established trend and seasonal patterns.

The first four variables representing the Washington State announcement are negative. This pattern suggests a temporary decline in purchases, but is likely to be the result of remaining random variation in the data. Only the first week is significantly different from zero at conventional levels of significance (p value is below 10 percent). Thus, there is some evidence suggesting the announcements did lead to reduced purchase levels in the week following the announcement.
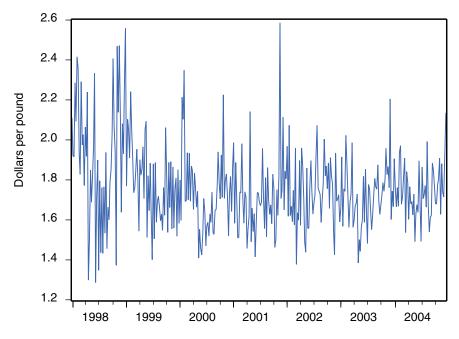
The estimated reduction of 55 percent in the week immediately following the announcement appears relatively large, but this estimate is not precise. The 95-percent confidence interval for the reduction ranges from a small increase to a more than 100-percent reduction. Again, like results from fresh beef, the most one can conclude is that there may have been a short-lived reduction as some consumers temporarily decided that beef was not as safe as it had been.

The preceding models do not account for the influence of retail prices. Adding prices may better reveal the magnitude and duration of possible adjustments to BSE announcements. Figure 9 shows the time plot of weekly inflation-adjusted prices for frozen beef, again adjusted by dividing by the corresponding weekly price of bread. Inflation-adjusted prices have been falling at an average of 1.2 percent per year. Contrasting the fresh and frozen beef markets, we see that fresh purchases have been falling and infla-tion-adjusted prices rising while frozen purchases have been rising (on average) and inflation-adjusted prices falling.

To show how much inflation-adjusted retail prices add to the explanation of the variation in quantity purchased, we estimate the model[6]

$$\ln y_t = \alpha t + \beta \ln P_t + \sum_{i=1}^{52} \gamma_i D_{it} + \varepsilon_t \quad t = 1, 2, ..., 364$$

Figure 9

Weekly U.S. inflation-adjusted retail price of frozen beef, 1998-2004
Inflation-adjusted prices for frozen beef dropped 1.2 percent annually between 1998 and 2004

Source: Economic Research Service/USDA, using data from the ACNielsen Homescan Panel, 1998-2004.

[6] Paralleling the model for fresh pur-chases, we also constructed a price for frozen poultry. The frozen poultry price was intended to represent the price of a substitute for frozen beef, since both frozen beef and frozen poultry are more processed than fresh meats. We estimated a regression also including the natural logarithm of the frozen poultry price divided by the price of bread. The estimated coeffi-cient was, as expected, positive and smaller in absolute value than the coefficient for frozen beef. However, the poultry coefficient did not meet conventional significance level tests. Further, we found that estimates of announcement impact coefficients were unaffected by inclusion or exclu-sion of the poultry price variable.

Both the quantity purchased and the inflation-adjusted retail price are transformed to natural logarithms. Results are in the left-most column of table 5. The (log transformed) price term is highly significant and indicates a price elasticity of -0.9. That is, a 1-percent increase in price typically induces a 0.9-percent decrease in quantity purchased.

We identify the impacts of the BSE announcements by adding 10 dummy variables indicating the 5 weeks following the Canadian announcement and the 5 weeks following the Washington State announcement. The model accounting for trend, seasonality, price, and the BSE announcements is

$$\ln y_t = \alpha t + \beta \ln P_t + \sum_{i=1}^{52} \gamma_i D_{it} + \sum_{j=1}^{5} \delta_j CAN_{jt} + \sum_{k=1}^{5} \delta_k WASH_{kt} + \varepsilon_t \quad t=1,2,...,364$$

Results are in the right-most column of table 5.

Estimated coefficients for all but 1 of the 10 announcement-effect dummy variables are negative, suggesting that the announcements decreased purchases. However, only one—again, the first week after the Washington State announcement—is different from zero at conventional significance

Table 5
Regression results from combined trend and seasonal models, accounting for price effects and BSE announcements

Independent variables in addition to trend and 52 seasonal dummy variables	Dependent variable: quantity of frozen beef	
	Time trend, seasonal, and price model	Time trend, seasonal, price, and BSE announcement model
	Estimated coefficient (p value)	
Ln(frozen beef price/ bread price)	-0.935291 (0.0000)	-0.950005 (0.0000)
CAN1		-0.017837 (0.9482)
CAN2		-0.195871 (0.4754)
CAN3		-0.147921 (0.5910)
CAN4		-0.053452 (0.8456)
CAN5		-0.192480 (0.4834)
WASH1		-0.633688 (0.0218)
WASH2		-0.163512 (0.5523)
WASH3		0.307697 (0.2635)
WASH4		-0.281413 (0.3076)
WASH5		-0.117712 (0.6685)
Summary statistics		
R^2	0.750452	0.758032
Adjusted R^2	0.707788	0.707218
Durbin-Watson	1.943001	1.946904

Source: Economic Research Service/USDA.

levels. That coefficient suggests purchases were down sharply for 1 week: purchases fell 63 percent. This coefficient is estimated more precisely than the corresponding coefficient in the model without a price variable, but the 95-percent confidence interval is still quite wide. The interval extends from a 9-percent reduction to a more than 100-percent reduction.

Table 6 shows that forecasting prices, either with a linear trend or in combination with the seasonal dummy variables, yields out-of-sample forecasts that are either lower than the observed prices or within the range of forecasts. That is, there is no evidence to suggest that retail prices were especially low immediately after either BSE announcement.

Like the results for fresh beef, the estimated regressions for frozen beef purchases point to the possibility (but not proof) that the Washington State announcement did reduce purchases. There is no evidence that the Canadian announcement influenced purchases. For frozen beef, there is no evidence of impacts beyond 1 week. If some consumers were temporarily fearful of beef, most were convinced that safety was no longer compromised within a short time.

Table 6
Comparing frozen beef price forecasts with observed prices after the BSE announcements

| Week beginning | Observed price | | Forecast price | | | |
	Unadjusted	Inflation adjusted	Linear trend	Trend and seasonal model	Linear trend, inflation adjusted	Trend and seasonal model, inflation adjusted
			Dollars per pound			
12/24/03	1.99	1.67	1.95	2.13	1.67	1.81
12/31/03	2.27	1.91	1.95	2.00	1.67	1.74
5/21/03	1.86	1.56	1.91	1.77	1.66	1.50
5/28/03	1.86	1.60	1.91	1.82	1.66	1.59

Source: Economic Research Service/USDA.