Changing Seasonal Patterns in the Poultry Market

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ABSTRACT: The role of seasonality in modeling agricultural markets is well recognized. However, traditional approaches to account for seasonality assume that seasonal pattern is constant, even though some evidence of changing seasonal pattern exists in the literature. This paper seeks to explore the impact of incorporating changing seasonal pattern into poultry market modeling.

Keywords: seasonality, trigonometric variable, seasonal frequency.

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1. Introduction

Many agricultural markets exhibit characteristics of significant seasonality both in prices and quantities. The traditional approach for accounting for seasonality in modeling demand relationships has been to use dummy variables. Examples include Malone an Reece (1976), Haidacher et al. (1982), Wohlgenant and Hahn(1982), Martinez et al. (1986), Brester and Schroeder(1985) etc. Another approach to capture seasonal differences is to use harmonic analysis. This approach makes use of the periodic properties of trigonometric variables to characterize seasonality, e.g., Kesavan and Buhr (1995).

Both of these approaches assume a priori a constant seasonal pattern. Even though some evidence of changing seasonal patterns exists in the poultry market literature, there has been little empirical testing of this assumption. For example, Lasley et al. (1985) noted that turkey consumption for the first three quarters of the year changed much more than for the fourth quarter between 1960 and 1980. Witzig (1977) suggested that seasonal patterns for broiler prices in the early 1970's were quite different from those in earlier years. Schrimper (1998) indicated that the seasonal pattern of turkey and broiler consumption and prices seems to exhibit significant variability.

This paper explores the impact of incorporating changing seasonal pattern into poultry market modeling. In particular, procedures provided by Arnade and Pick (1998) are followed in creating a variable that consists of an interaction term between a trend variable and a trigonometric variable representing a particular frequency. This variable can then be used as an exogenous variable in the economic model to detect and account for changes in the seasonal cycle.

The rest of the paper is organized as follows. Section 2 estimates two versions of an inverse demand equation. Model 1 assumes constant seasonality, while model 2 includes variables to capture changing seasonal pattern. Section 3 presents the empirical results. The last section contains a summary and conclusions.

2. Model Specification

In Arnade and Pick (1998), a simple method was developed to test and account for a changing seasonal pattern using harmonic analysis. They used a variable consisting of an interaction term between a trend variable and a trigonometric variable representing a particular seasonal frequency. They show that this variable can be used as an explanatory variable to detect changes in the seasonal cycle. In this paper, inverse demand equations for broilers and turkey will be estimated using similar procedure.

The basic model is specified as

$$p_{i,t} = a_0 + b_0 p_{i,t-1} + b_1 q_{i,t} + \sum_{j=2}^{4} b_j p_{j,t} + b_5 m_t + b_6 tr_t + \sum_{r=1}^{6} b_{7,r} f_r + \sum_{s=1}^{6} b_{8,s} g_s + \varepsilon_t \quad ,$$

$$i=1,\ 2 \qquad (3)$$

where $p_{i,t}$ is the log of own price for either broilers or turkey at time *t*, $p_{j,t}$ is the log of the price of substitutes representing substitution effects. We consider turkey and broiler as substitutes for each other as well as beef and pork. m_t is the log of per capita monthly income, tr_t is a time trend variable. f_r and g_s are the trigonometric variables, where $f_r = \cos(\frac{2r}{12}\pi tr)$, and $g_s = \sin(\frac{2s}{12}\pi tr)$. The elements of f_r and g_s are cyclical processes at the seasonal frequencies $(\frac{2r}{12}\pi)$ and $(\frac{2s}{12}\pi)$. The coefficients $(b_{7,r}, b_{8,s})$ represent the contribution of each cycle to the seasonal processes. The one-period lagged price ($p_{i,t-1}$) reflects the partial adjustment of price.

The above specification does not consider varying seasonality. We will refer to this as model 1. In order to evaluate the effect of non-constant seasonality, consider the following (Chow, 1983)

$$\beta_1 \cos(\bullet) + \beta_2 \sin(\bullet) \tag{4}$$

The dot inside the parentheses represents the arguments of the function. The amplitude of the function is

$$(\beta_1^2 + \beta_2^2)^{1/2} \tag{5}$$

According to Arnade and Pick (1998), there are two kinds of seasonal trends that can be monitored by using an interaction term between a trend variable and the trigonometric variable. One is amplitude shift and the other is phase shift.

Introducing the interaction term into model 1:

$$\beta_1 \cos(\bullet) + \alpha_1 * tr * \cos(\bullet) + \beta_2 \sin(\bullet) + \alpha_2 * tr * \sin(\bullet) \tag{6}$$

where *tr* is a variable that exhibits a trend effect over the time period. If either α_1 and/or α_2 are significant, then from the definition of amplitude in eq. (5), we can conclude that the amplitude of the seasonal cycle is changing over time.

The test for phase shift is more complex. Such a shift changes the starting and ending points or the location of a seasonal cycle. The location of a cycle at a particular frequency depends on a weighted average of the cosine and sine variables. These weights are determined by the parameters of the trigonometric variables in the estimated model. If the location of the seasonal cycle is displaced by an amount τ , then $\tan(\tau)$ can be shown to be proportional to β_1 / β_2. Thus, changes in the relative coefficients of the trigonometric variables can represent a phase shift in the season. If there is no phase shift, then the tangent of displacement τ without the interaction term equals the tangent of displacement in the presence of the interaction term. Thus, when no phase shift occurs in the seasonal cycle, the following holds:

$$\frac{\alpha_2 * trend + \beta_2}{\alpha_1 * trend + \beta_1} = \frac{\beta_2}{\beta_1} \quad , \tag{7}$$

which is equivalent to the restriction $\alpha_2 = \beta_2 \alpha_1 / \beta_1$. To test for phase shift, significance of the restriction can be tested. If imposing the restriction does not significantly change the fit of the model, then the hypothesis of no phase shift can not be rejected.

Our technique will be as follows.

Step 1. The demand equation (3) is estimated without considering seasonal trend.

Step 2. For the frequencies that are shown to be significant in step 1, we use the above method to test for amplitude and phase shift. Amplitude test was performed by setting both interaction terms equal to zero and testing against the unrestricted model. The phase test was done using Wald test.

Step 3. For the frequencies that exhibit changing seasonal patterns, we include the interaction terms in the model. This is referred to as model 2. Model 2 is estimated to determine how the estimated coefficients change.

3. Empirical Results

Monthly data for broiler and turkey consumption and price for the period January 1976 through December 1995 are obtained from *Poultry Year Book* (USDA). Price data for beef and pork are obtained from *Red Meat Yearbook* (USDA). Monthly CPI and monthly per capita disposable income are obtained from *Federal Reserve Bank*. The retail prices were deflated by monthly CPI (1982-1984 =100).

Estimated results are reported in table 1 and table 2.

Estimation of model 1 shows that most of the trigonometric variables are significant for turkey. These include $f_1, f_5, g_2, g_3, g_4, g_5$. The Broiler equation has 2 significant trigonometric variables, these are f_1 and g_2. This indicates that turkey shows stronger evidence of seasonality than broiler.

The amplitude and phase shift tests for these frequencies are given in table 1. The significance levels for both tests are 5%. For turkey, we reject the null hypothesis of no amplitude shift at all the frequencies considered. For broiler, we reject the null hypothesis of no amplitude shift at $\frac{2}{6}\pi$, but could not reject the null at $\frac{1}{6}\pi$. Phase shift test results show that there is no much evidence of phase shift for both turkey and broiler. We could not reject the null hypothesis of no phase shift at all frequencies considered except for turkey at $\frac{1}{6}\pi$.

The test results show that turkey shows much stronger evidence of changing seasonal pattern than broiler.

Next we compare the estimated coefficients from the two models. Bear in mind that the only difference between the two models is that model 1 does not allow for changing seasonal pattern, while model 2 includes interaction terms to capture varying seasonality. Price flexibility and income elasticity results are given in table 2.

From table 2, we find that own price elasticity for turkey is very sensitive to the two specifications. Without considering changing seasonal patterns, this estimate is 0.0079, which is insignificant. But in model 2 that allows for changing seasonal pattern, the estimate is –0.0473, and is significant. For income elasticity of turkey, the estimate changes from –6.6599 in model 1 to 2.1870 in model 2. The coefficient estimates for beef and pork are also different for the two models, though insignificant in both cases.

When we compare the estimated coefficients for broiler, we do not find significant differences between the two models. Own price elasticity is –0.0956 in model 1, and -0.0921 in model 2. Income elasticities are also quite close in the 2 models: 3.7390 in model 1 and 3.8005 in model 2. The coefficients for beef and pork are significant in the broiler equation.

In sum, the coefficients in turkey equation are quite sensitive to the two specifications and the coefficients in broiler equation are not. This is not too surprising considering the fact that turkey consumption shows stronger evidence of variation in seasonal pattern than broiler. Notice that the estimated coefficients for beef and pork price are not significant in the turkey equation, but significant in the broiler equation. On the contrary, fewer trigonometric variables and interactions are significant in the broiler equation than those in the turkey equation. This means that, seasonal variation in turkey consumption is a very important factor in explaining variations in consumption demand relations. Thus, it is misleading to ignore the fact that the seasonal pattern is not constant. Even though seasonality also exists for broiler, the degree of variation in seasonal pattern is not as great as for turkey. Variation in consumption demand relations is mostly explained by other factors like income, substitution effects etc. Thus ignoring the changing seasonal pattern will not have much effect on estimation.

4. Conclusion

The role of seasonality in modeling agricultural markets is well recognized. However, traditional approaches to account for seasonality assume that seasonal pattern is constant, even though seasonal pattern may be changing over time.

This paper provides empirical evidence that the seasonal pattern for both turkey and broiler consumption is not constant. This implies that economic models that allow for changing seasonal patterns are more appropriate. The results of using Arnade and Pick (1998) method to account for changing seasonality in demand equations show that, in the case of high variation in seasonal pattern, like turkey consumption, the price and income elasticities are quite sensitive to whether or not the model allows for changing seasonality. This implies that in estimating poultry (as well as perhaps other agricultural products) demand equations, if data shows strong evidence of changing seasonality, the selected model should be able to account for this variation.

Table1. Amplitude and Phase shift test results

	Amplitude[1]		Phase[2]	
	Turkey	Broiler	Turkey	Broiler
$\frac{1}{6}\pi$	12.40*	0.94	6.15 (0.01)*	0.86 (0.35)
$\frac{2}{6}\pi$	10.45*	5.09*	1.51 (0.22)	0.27 (0.60)
$\frac{3}{6}\pi$	5.83*		0.01 (0.93)	
$\frac{4}{6}\pi$	5.33*		0.03 (0.86)	
$\frac{5}{6}\pi$	4.28*		0.43 (0.51)	

[1] Amplitude test statistics are F-statistics with corresponding degrees of freedom.

[2] Phase shift test statistics are χ^2-statistics with 1 degree of freedom.

p-values are in parentheses for phase shift tests.

* statistically significant at 5% level.

Table2. Sensitivity of coefficient estimates

	Turkey			Broiler	
	Model 1	Model 2		Model 1	Model 2
intercept	-0.1554	-0.6590	intercept	-2.95*	-2.8749*
p_{t-1} (turkey)	0.8366*	0.8168*	p_{t-1} (broiler)	0.7938*	0.7995*
q_t (turkey)	0.0079	-0.0473*	q_t (broiler)	-0.0956*	-0.0921*
p_t (broiler)	0.1185*	0.1236*	p_t (turkey)	-0.0677	-0.0589
p_t (beef)	-0.0060	0.0093	p_t (beef)	0.0852*	0.0772*
p_t (pork)	-0.0037	-0.0069	p_t (pork)	0.1117*	0.1038*
trend	0.0003	-0.0002	trend	-0.0005*	-0.0004*
income elasticity	-6.6599	2.1870	income elasticity	3.7390*	3.8005*

* statistically significant at 5% level.

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