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Issues of Demand Specification and Industry Structure in Turkeys and Broiler Chickens

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ABSTRACT

Factors unique to the turkey industry suggest that conclusions concerning market structure and demand specification drawn from aggregate poultry data cannot necessarily be extrapolated to the turkey industry. The Wu-Hausman endogeneity test is used to examine demand specifications and industry structure specifically for turkey meat. In contrast to general poultry, quantity—not price—is found to be predetermined in demand models that use annual turkey data. Quarterly demand analysis suggests this result stems from biological cycles that limit a producer's ability to react to price change and the use of a weighted average for determining price and quantity.

Key Words: *demand analysis, endogeneity, market structure, poultry industry, turkeys.*

Broiler chickens and turkeys are the primary commodities in the U.S. poultry meat industry. By far, however, broiler chickens (young chickens raised for meat) are the dominant species in an aggregate poultry commodity. Consequently, studies that have used aggregate poultry data are essentially analyzing the broiler chicken industry rather than the "other" poultry which account for the remaining share of production. However, factors unique to the turkey industry argue against the approach of aggregating commodities in a poultry demand model and increase the importance of individual turkey demand models.

While many researchers have focused on issues of demand estimation and industry structure in the livestock and poultry sectors, few have addressed these concerns specifically for the U.S. turkey industry. Previous poultry studies have either tended to disregard turkey and have concentrated solely on broiler chickens (e.g., Knoeber and Thurman; Moschini and Meilke, Wohlgenant and Hahn) or have analyzed an aggregate poultry commodity dominated by broiler chickens (Thurman 1986, 1987).[1] To address limitations in previous analyses of poultry demand and industry structure, the current study investigates issues

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[1] An exception is the work of Chavas and Johnson. However, their study concentrates on specifying lag distributions in dynamic supply functions and is not directed at demand specification issues.

of demand specification and industry structure exclusively for the turkey subsector.

This study proceeds by first reviewing the results of Thurman's 1987 study of the poultry industry which then motivates consideration of demand analysis specific to the turkey industry. After identifying some of the major differences between the turkey and the broiler chicken industries, the two major species used in aggregate poultry data, we argue that there is sufficient evidence to suggest that these two industries are distinct enough to merit independent demand analysis. The issue of demand analysis and specification is next addressed. Specifically, the question of treating price or quantity, if either, as a predetermined variable in the demand equation is investigated by using the Wu-Hausman endogeneity test. Finally, results from the specification of turkey meat demand are compared to issues of specification and industry structure in aggregate poultry meat data.

Aggregrate versus Disaggregate Poultry Data

A commonly accepted practice among researchers in studies addressing demand analysis and industry structure is to consider an aggregate poultry commodity. Such is the case with Thurman's 1987 work addressing demand stability and industry structure in the poultry industry. Thurman concludes that poultry price is predetermined in annual demand models and suggests that the industry is characterized by a perfectly elastic supply curve. However, a priori conclusions drawn from this study cannot necessarily be extrapolated to individual poultry industries such as turkey. The reason is relatively straightforward: aggregate poultry data is dominated by broiler chicken data which accounts for more than 80 percent of all poultry consumption and production (Madison). Consequently, even though such studies may be highly appropriate for analyzing aggregate poultry demand—and in some instances broiler industry analysis—they may not be applicable to individual poultry subsectors.

Consider as evidence the consumption differences between broilers and turkeys. While per-capita consumption of both commodities increased significantly over the last few decades, substantial differences occurred in the timing and magnitude of the growth periods (Figure 1). Per-capita chicken consumption increased dramatically in the 1960s, by as much as 55 percent between 1960 and 1970. Strong consumption growth has been sustained in the following decades with projected growth in the 1990s of nearly 40 percent. The story for per-capita turkey consumption is somewhat different. Turkey consumption skyrocketed in the 1980s, increasing by over 70 percent, but growth since then has slowed. Total growth in per-capita consumption during 1990–1998 was 2 percent (USDA). Consequently, although the long-run consumption trend for both poultry commodities has been positive, substantial differences in timing and magnitude suggest that analysis using aggregate annual time series poultry data will not reflect the individual characteristics of turkey consumption vis-a-vis broiler consumption.

Perhaps a more revealing difference affecting demand specification arises from the production cycles of each species. In contrast to broilers, which have a short five-to-six-week production cycle, the production cycle for turkey poults is approximately five months from the time of hatching to slaughter. Turkeys reach an acceptable market age and weight between four to seven months. Given the longer production cycle, the ability of turkey producers (either independent producers or integrators) to react to short-run price fluctuations is diminished relative to their counterparts in the broiler chicken industry. This suggests that turkey producers may not be able to react to price changes resulting from demand shocks as do their broiler counterparts. Such a result would have two important implications. First, it implies that turkey supply is relatively inelastic. Second, it suggests that Thurman's conclusion that poultry price is predetermined in annual data may not be easily extrapolated to annual turkey demand models.

An additional factor lending insight into the argument that price may not be predetermined in turkey demand models is the reali-

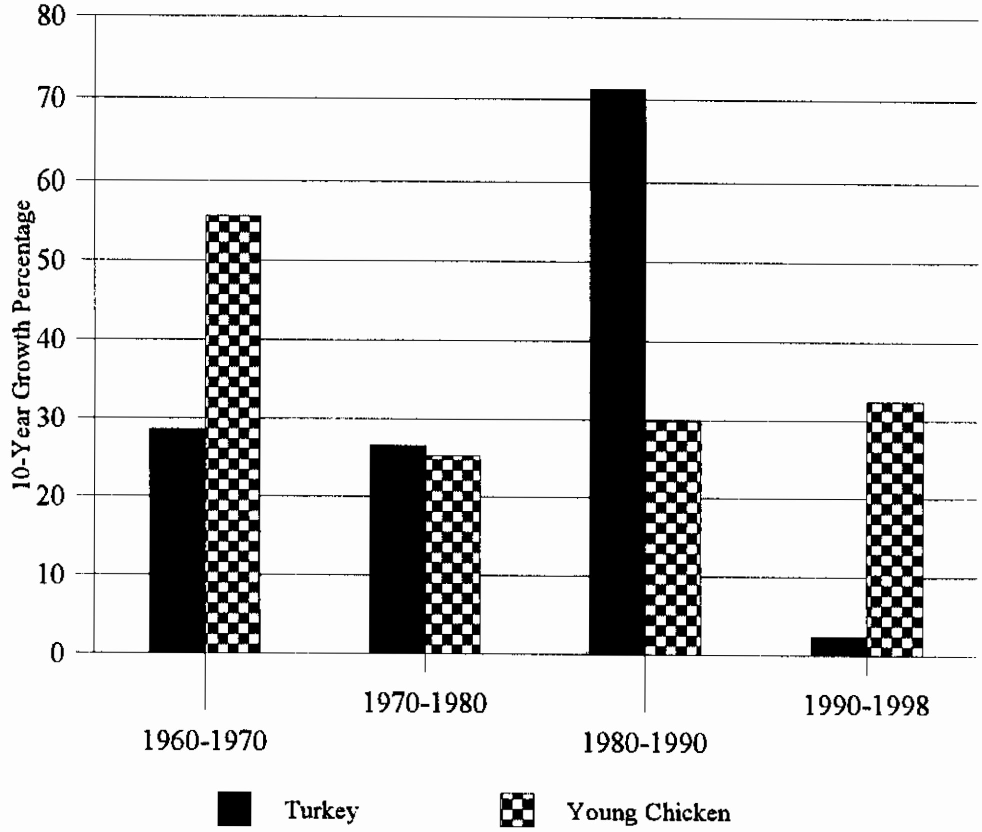

Figure 1. Percentage changes in per-capita consumption turkey and young chicken, 1960–1998

zation that turkey consumption is highly seasonal. In 1960, more than 50 percent of all turkey consumption took place during the last three months of the year. In 1993, more than 35 percent of yearly turkey consumption still occurred during the last quarter with consumption in November, not surprisingly, being more than twice and in some instances three times as high as any other month excluding October (*Poultry Yearbook*). This implies that for annual data weighted by monthly quantity, more weight would be placed on the holiday months when the majority of turkey meat reaches the market. If during these months price is used to clear the market once the quantity of turkeys is established, this would suggest that it may not be relevant to consider price as predetermined. Alternatively, if during the holiday months retail turkey price is fixed and turkey serves as a loss-leader at the retail level, it may be plausible to treat price as a predetermined variable.

The unique characteristics of the turkey industry, specifically the differing production cycles and marketing and consumption patterns, increase the value of studies specifically addressing the turkey industry. Given then that there is sufficient motivation to evaluate turkey demand independently, the next issue is how to best specify the demand equation.

Demand Specification

Demand equations may be specified in one of three ways. First, the textbook treatment is a system of simultaneous equations that treat both price and quantity as endogenous variables in a supply-and-demand framework. Alternatively, based on consumer preferences and the structure of the particular industry, there are cases when either price or quantity is argued to be predetermined in demand. For instance, given a price-supported commodity, price may be treated as an exogenous variable and quantity as an endogenous one provided that the support price is binding during the period investigated. A more common way to interpret the argument for predetermined price is the concept of fixed short-run retail prices. Again, for data evaluated within a particular time it is sometimes argued that price adjustments do not occur. Rather, quantity adjusts to clear the market. Finally, price may be predetermined in annual data in a competitive industry that faces constant returns to scale and elastic factor supplies. In this case, price is determined by input costs and demand determines quantity.

Arguments for predetermined quantity also are found in the literature. The most popular argument suggests that supply is perfectly inelastic because of the perishability of nonstorable commodities. Here, production decisions made well in advance of harvest cannot be altered at the time of market. Consequently, quantity is fixed and price adjusts to clear the market.

It is not clear, a priori, if either consumer preferences or the structure of the turkey industry would cause price or quantity, if either, to be predetermined in an annual turkey demand equation. Thurman's (1987) research suggests that price is predetermined for demand in annual poultry data for the period between 1955 and 1981. However, since he considers aggregate poultry data dominated by broiler chickens, it is not clear that this would hold for turkeys. Consequently, two empirical questions must be investigated. First, can price be treated as a predetermined variable in a turkey demand equation that uses annual data? Second, is there evidence to suggest that quantity may be predetermined? The question of whether price or quantity or neither can be treated as predetermined in a demand equation is examined by using the Wu-Hausman test.

The Wu-Hausman Endogeneity Test

The Wu-Hausman test for endogeneity was developed by Wu in his 1973 paper and independently by Hausman in a 1978 article. The intuition behind the Wu-Hausman test for misspecification is relatively straightforward. In a one-variable linear demand equation where the right-hand side (RHS) variable is exogenous, an OLS estimator of the coefficient of the right-hand side variable will be unbiased and consistent. Alternatively, if the RHS variable is endogenous, the OLS estimator is no longer unbiased and consistent. In this case, however, an instrumental variable (IV) estimator will provide a consistent estimate of the coefficient on the RHS variable. The Wu-Hausman test measures the significance of the difference between the OLS and the IV estimates. If the difference is large relative to its standard error, and since the IV estimator is consistent, the OLS estimator must be inconsistent, therefore implying endogeneity.

A more formal development of the Wu-Hausman test for endogeneity is this. Consider a linear demand equation with price as the RHS variable and quantity as the left. Under the null hypothesis of no misspecification in the demand equation, both an OLS estimator, $\hat{b}$, and an instrumental variables estimator, b^*, will be consistent estimators of the coefficients on right-hand side variables. If the null hypothesis is true, the difference between the two estimates, $q = \hat{b} - b^*$, will have a probability limit of zero. If misspecification is present, then the probability limit of q will differ from zero. The Wu-Hausman procedure tests whether this relationship holds asymptotically by evaluating the following test statistic:

$$(1) \quad W = (\hat{b} - b^*)'[\hat{V}(q)]^{-1}(\hat{b} - b^*).$$

Here, $[\hat{V}(q)]$ is a consistent estimator of $V(q)$, the covariance matrix of the difference. Under the null hypothesis of no misspecification, W is distributed asymptotically chi-square with the degrees of freedom equal to the number of variables under question. Construction of this test statistic is simplified by noting that under the null hypothesis, asymptotically $V(q) = V(b^*) - V(\hat{b})$ (Wu 1978, Thurman 1986).

Endogeneity Tests for Annual U.S. Turkey Meat

The Wu-Hausman endogeneity test is applied to both a quantity-dependent and a price-dependent model of annual turkey demand. The quantity-dependent model, where price is considered predetermined, is specified as:

$$(2a) \quad Q_t^T = \beta P_t^T + X_t'\alpha + \epsilon_t,$$

and can be estimated via ordinary-least squares (OLS) or instrumental variables. In equation (2a), Q_t^T is the log of annual per-capita turkey consumption, P_t^T is the log of real retail turkey price and X_t' is a vector of logged exogenous variables representing the real prices of chicken, pork, beef and per-capita disposable real income, P_t^{CK}, P_t^{PK}, P_t^{BF}, DI_t. Similarly, the price-dependent version of the demand model is described as:

$$(3a) \quad P_t^T = \theta Q_t^T + X_t'\gamma + \nu_t.$$

Two-stage least squares (2SLS) is the instrumental variables technique chosen in the case of right-hand side endogeneity. The instruments used are X_t' and a vector of supply shifter variables, M_t', where, $M_t' = (P_t^{CN}, P_t^{BM}, P_t^{IG}, P_t^{EN}, P_t^{L}, FD_t)$. Here, the instruments are the logged real prices of corn and soybean meal; price indices for industrial goods, energy, and labor; and the quantity of feed consumed by a 20-week-old tom turkey included as a proxy for technology. The time period analyzed is 1960 to 1995. Descriptions and sources for all variables used in this study are provided in the Appendix.

The Wu-Hausman test statistic was calculated for both the model of predetermined price and for the model of predetermined quantity. The null hypothesis of predetermined price was strongly rejected, but the hypothesis of predetermined quantity could not be rejected. However, first-order autocorrelation was present in the OLS model when quantity was on the left-hand side (the first-order autocorrelation coefficient for the residuals in the OLS model was 0.40). The autocorrelation in this model makes the asymptotic arguments for the Wu-Hausman test statistic void.

Thurman (1987) discovered similar serial correlation problems in his annual poultry data and discusses why residuals in annual consumer demand equations may be serially correlated. He concluded that the relationship between poultry and pork changed from one of substitutes to independent goods in the early 1970s. Contemporaneously, the demand for poultry meat increased. The possibility of a structural change in turkey demand was investigated using time period dummies and time-price interactions. Similar to poultry, the data support a change in the relationship between turkey and pork. In addition, the data suggest a shift in the demand for turkey meat in the mid 1980s. Including a pork price slope shift in the mid-1970s and an intercept shift in 1985 reduces the serial correlation. Plausible reasons for the structural change are the introduction of new product development in the mid-1980s (e.g., ground and formed turkey products such as turkey bologna, turkey ham and turkey hot dogs) and the movement toward increased consumption of white meat in the mid-1970s. Moschini and Meilke provide further empirical evidence of structural change in the poultry industry during the 1970s.

Equations (2a) and (3a) were estimated again with the addition of a pork price-dummy interaction term and an intercept shifter:

$$(2b) \quad Q_t^T = \beta_1 P_t^T + X_t'\alpha + \beta_2 PKP75 + \beta_3 D85 + \epsilon_t,$$

$$(3b) \quad P_t^T = \theta_1 Q_t^T + X_t'\gamma + \theta_2 PKP75 + \theta_3 D85 + \nu_t.$$

The variable *PKP75* is the product of a dummy variable, assigned a value of zero prior and including 1975 and one after, and the log of retail pork price. The second new variable is a dummy variable set equal to zero in the years before 1985 and one from 1985–1995. Results from both the OLS and 2SLS estimation for the two models are presented in Table 1, with the Wu-Hausman test statistic and its associated p-value shown in the final row.

The first column of Table 1, (A), provides the results for the price-dependent demand

Table 1. Estimates of Quantity- and Price-Dependent Annual Demand Equations and the Wu-Hausman Test

		(A)	(B)	(C)	(D)
OLS:	*Intercept*	2.205	(0.992)	2.293	(1.255)
	P^T	—	—	−1.016	(0.132)
	Q^T	−0.667	(−0.087)	—	—
	P^{CK}	0.271	(0.114)	0.113	(0.153)
	P^{PK}	0.188	(0.094)	0.177	(0.119)
	P^{BF}	0.244	(0.106)	0.242	(0.135)
	DI	0.065	(0.110)	0.233	(0.130)
	PK75	−0.013	(0.004)	−0.016	(0.005)
	D85	0.133	(0.037)	0.217	(0.037)
	R^2	0.990		0.987	
	Durbin-Watson	2.119		2.039	
2SLS:	*Intercept*	2.202	(0.993)	3.030	(1.439)
	P^T	—	—	−1.371	(0.206)
	Q^T	−0.652	(0.103)	—	—
	P^{CK}	0.279	(0.117)	0.329	(0.192)
	P^{PK}	0.188	(0.094)	0.254	(0.137)
	P^{BF}	0.244	(0.106)	0.333	(0.156)
	DI	0.058	(0.114)	0.134	(0.151)
	PK75	−0.013	(0.004)	−0.018	(0.006)
	D85	0.130	(0.039)	0.204	(0.042)
	R^2	0.989		0.983	
	Durbin-Watson	2.183		2.242	
		W-H Test Statistic	*p*-value	W-H Test Statistic	*p*-value
		0.072	0.789	5.111	0.024

Here, columns (A) and (C) show the estimates of the coefficients for the price- and quantity-dependent annual demand models, respectively, and columns (B) and (D) show the standard errors of the coefficients.

model while the second column, (B), shows the standard errors of the estimates. Columns (C) and (D) report analogous results for the quantity-dependent version. The small *p*-value for the quantity-dependent model reported in the final row of Column (D) suggests that there is very little agreement between the null hypothesis of predetermined price and the data. Alternatively, the results reported in Columns (A) and (B) cannot reject predetermined quantity. Consequently, there is a strong argument for treating quantity as predetermined when annual data are used to estimate turkey demand.

Why would annual poultry data suggest a structure where price is predetermined but quantity is not, and annual turkey data suggest the opposite? Recall that predetermined quantity implies a perfectly inelastic (vertical) supply curve, whereas predetermined price suggests a perfectly elastic (horizontal) supply curve. Two factors may account for this situation in the turkey industry. First, turkey consumption is still relatively seasonal with a greater percentage of consumption occurring during the holiday season in the fourth quarter than in each of the previous three quarters. Moreover, turkey meat is generally consumed within two months of processing. Annual data that use a weighted average for determining price and quantity will place heavier weights on the holiday months. During these months it is plausible that price adjusts to clear the market of turkeys that were produced either earlier in the year and frozen or, more likely, produced primarily for the holiday market.

Second, given the relatively longer production cycle, a producer's ability to react to price change (whether an independent producer or an integrator) is limited. Knoeber and Thurman suggest that in the broiler chicken industry, integrators increase production by increasing flock sizes when broiler prices rise. However, production decisions regarding turkeys are made at least five months before harvest, thereby decreasing a producer's ability to adjust quantity and react to price change.

Although the seasonal nature of turkey production and consumption provides insight into why annual data support the hypothesis of predetermined quantity, not price, it does not reveal whether which, if indeed either, of these explanations might hold. To more fully investigate these explanations, it is necessary to investigate a quarterly demand model.

Endogeneity Tests for Quarterly U.S. Turkey Meat

Quantity-dependent and price-dependent models of turkey demand are again estimated, but this time with quarterly data rather than annual data. The quantity-dependent model is specified as:

$$\text{(2c)}\quad Q_t^T = \beta_1 P_t^T + X_t'\alpha + \beta_2 PKP75 + \beta_3 D85 + \beta_4 P_t^{Q4} + \beta_5 q_1 + \beta_6 q_2 + \beta_7 q_3 + \epsilon_t.$$

Equation (2c) is analogous to the annual demand equation in (2b) with two exceptions. First, due to the seasonal nature of turkey consumption, quarterly dummy variables for the first, second and third quarters (q_1, q_2 and q_3) are included. Second, because it is hypothesized that the price-quantity relationship during the holiday months may differ from other quarters, a fourth quarter-price interaction term (P_t^{Q4}) is included. All other variable are as previously defined.

Similar to equation (3b), the price-dependent version of the quarterly demand model is:

$$\text{(3c)}\quad P_t^T = \gamma_1 Q_t^T + X_t'\lambda + \gamma_2 PKP75 + \gamma_3 D85 + \gamma_4 Q_t^{Q4} + \gamma_5 q_1 + \gamma_6 q_2 + \gamma_7 q_3 + v_t.$$

Here, Q_t^{Q4} is a quantity consumed-fourth quarter interaction term and all other variables are as previously defined.

Equations (2c) and (3c) are estimated using OLS and 2SLS. In the case of 2SLS, the instruments used are the same as those used in estimating the annual version (X_t' and M_t') as well as the log of beginning cold storage in the previous quarter ($COLD_{t-1}$). Because of the availability of data, the time period analyzed is 1970–1996, rather than the 1960–1995 period used in the annual model.

As was the case with annual data, autocorrelation exists in the price-dependent version (coefficient for the residuals in the OLS equation was 0.48). However, the autocorrelation is well modeled as an AR(3) process. To account for this, the residuals from (3c) were used to estimate the autocorrelation coefficients. The estimated autocorrelation coefficients were then used to transform the original data and the resulting quasi-differenced model was estimated. Similar corrections were made for the 2SLS model. The quantity-dependent demand model did not show significant autocorrelation, thus no corrections were made for serial correlation. Results for both the OLS and 2SLS estimation for the price-dependent and quantity-dependent quarterly models are presented in Table 2.

Because a fourth quarter interaction term is included in the quarterly demand models, two versions of the Wu-Hausman procedure are used to test for predetermined price and predetermined quantity. In the case of the quantity-dependent model, the first version, referred to here as a *single test,* measures the significance of the difference between the OLS and the IV estimates of only the price variable coefficient. Because the single test excludes the interaction term, the test is a test of predetermined price in the first three quarters of the year. Alternatively, the *joint test* refers to the case where both price and the price-fourth quarter interaction term are evaluated and is a test for predetermined price in all four quarters.[2] Analogous tests are used for the

[2] In the case of the single test, $\hat{b}$ and b^* in equation (1) are scalars. In the joint test, $\hat{b}$ and b^* are 2×1 vectors consisting of the estimators of the coefficients on price(quantity) and the price(quantity)-fourth quarter interaction term.

Table 2. Estimates of Quantity- and Price-Dependent Quarterly Demand Equations and the Wu-Hausman (W-H) Test

		(A)	(B)	(C)	(D)
OLS:	*Intercept*	4.032	(−0.767)	−5.757	(1.856)
	P^T	—	—	−1.216	(0.162)
	Q^T	−0.128	(−0.039)	—	—
	P^{CK}	0.419	(0.081)	0.184	(0.152)
	P^{PK}	0.043	(0.082)	0.069	(0.126)
	P^{BF}	0.268	(0.104)	0.516	(0.146)
	DI	−0.584	(0.124)	0.610	(0.182)
	PK75	0.002	(0.005)	−0.020	(0.007)
	D85	0.088	(0.033)	0.191	(0.045)
	P_T^{Q4}	—	—	0.826	(0.072)
	Q_T^{Q4}	−0.300	(0.053)	—	—
	q_1	−0.596	(0.111)	3.118	(0.350)
	q_2	−0.584	(0.107)	3.235	(0.349)
	q_3	−0.547	(0.100)	3.489	(0.350)
	R^2	0.945		0.971	
	Durbin-Watson	1.658		1.844	
2SLS:	*Intercept*	3.976	1.020	−4.077	(0.280)
	P^T	—	—	−1.397	(0.274)
	Q^T	−0.189	(0.076)	—	—
	P^{CK}	0.438	(0.080)	0.268	(0.188)
	P^{PK}	0.028	(0.084)	0.095	(0.126)
	P^{BF}	0.274	(0.106)	0.506	(0.150)
	DI	−0.479	(0.166)	0.443	(0.237)
	PK75	0.00005	(0.005)	−0.020	(0.007)
	D85	0.101	(0.034)	0.203	(0.046)
	P_T^{Q4}	—	—	0.847	0.082
	Q_T^{Q4}	−0.360	(0.077)	—	—
	q_1	−0.745	(0.182)	3.226	0.398
	q_2	−0.726	(0.173)	3.336	0.398
	q_3	−0.676	(0.157)	3.590	0.399
	R^2	0.952		0.971	
	Durbin-Watson	1.722		1.899	
		W-H Test Statistic	*p*-value	W-H Test Statistic	*p*-value
	Single Test*	0.899	0.343	0.679	0.410
	Joint Test**	1.326	0.515	1.878	0.391

Here, columns (A) and (C) show the estimates of the coefficients for the price- and quantity-dependent quarterly demand models, respectively, and columns (B) and (D) show the standard errors of the coefficients.

* Single test refers to the case where q is a scalar and only the price (quantity) parameters are evaluated.

** Joint test refers to the case where q is a vector consisting of both price (quantity) parameters and price (quantity)-fourth quarter interaction term parameters.

price-dependent model. In either case, if quarterly turkey demand is well specified as an OLS regression, both the OLS estimators, $\hat{b}$ and the 2SLS estimators, b^*, will be consistent estimators of the coefficients on right-hand side variables and the Wu-Hausman test statistic in (1) will be relatively small.

Results from both the single and joint tests for the quarterly demand models are presented in the final two rows of Table 2. Columns (A) and (C) report the Wu-Hausman test statistic and Columns (B) and (D) report the associated *p*-value for the price-dependent and quantity-dependent models, respectively. Given the particular model analyzed for 1970–1996, neither predetermined price or predetermined quantity can be rejected in quarterly demand.

Conclusions

Recall that testing for predetermined price and quantity in quarterly turkey demand was motivated by not rejecting predetermined quantity in the annual demand model. The objective of the quarterly demand analysis was to explore whether predetermined price in annual data might be (1) the result of using a weighted average to determine price and quantity with more weight placed on the holiday months when price is used to clear the market of turkeys that were produced earlier, or (2) the result of biological production cycles that limited a producer's ability to quickly react to price change. In the first case one would expect to find predetermined quantity in the fourth quarter, but not necessarily in the first three quarters. In the second case one would anticipate predetermined quantity in all four quarters.

Endogeneity tests performed on the quarterly demand model reveal that predetermined quantity is neither rejected for the first three quarters of the year (the single test) nor for all four quarters of the year (the joint test).[3] Consequently, one cannot rule out the hypothesis that quantity is fixed in the fourth quarter and price adjusts to clear the market of turkeys that were produced primarily for the holiday market. However, the finding that quantity is also predetermined in the first three quarters as well suggests there is something more going on, such as a producer's limited ability to quickly adjust quantity in response to a demand shock. It therefore seems likely that both the production and the consumption characteristics of turkey meat may lead one to treat quantity as predetermined in annual demand models. However, in either case, this result conflicts with aggregate poultry data and one should be cautious in assuming that what holds for poultry demand and industry structure is applicable to turkey demand and industry structure as well.

[3] Although tests for both predetermined quantity and predetermined price were performed on the quarterly model, the motivation for analyzing a quarterly model was to explore the reason for finding predetermined quantity in annual data. Thus, discussion of the results is restricted to interpreting the endogeneity tests for predetermined quantity. The authors recognize that although the quarterly data and the particular functional form also do not rule out predetermined price that both conclusions are mutually inconsistent and not possible at the same time.

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APPENDIX

All variables are in natural logarithm form. Retail prices and disposable income are deflated by the consumer price index. Input prices are deflated by the producer price index. All prices are evaluated in terms of 1990 dollars.

P^T = average retail turkey price, cents per pound; Source: *Poultry Yearbook*, 1994, ERS #916

Q^T = per capita turkey consumption in pounds; Source: *U.S. Egg and Poultry Statistical Series*

P^{CK} = average retail whole fryer price, cents per pound; Source: *Poultry Yearbook*

P^{PK} = retail pork price per pound, cents per pound; Sources: *Livestock and Meat Statistics*; *Red Meat Yearbook*

P^{BF} = retail choice beef price per pound, cents per pound; Sources: *Livestock and Meat Statistics*; *Red Meat Yearbook*

DI = real per-capita personal disposable income; Source: Economic Report of the President

P^{CN} = cash corn price—#2, Chicago, dollars/bu.; Source: *Feed Situation and Outlook*, various issues

P^{BM} = price of soybean meal, 44 percent, Decatur, dollars/ton; Source: *Feed Situation and Outlook*, various issues

P^{IG}, P^{L} = industrial goods price index, manufacturing wage index, base year = 1990; source: IFS

P^{EN} = producer price index for fuel; Source: Producer Price Indexes by Stage of Processing, Economic Report of the President

FD = feed consumed by a 20-week-old tom turkey; Source: *Turkey World*, various January issues.

$COLD$ = beginning cold storage stocks, 1000 pounds; Source: *Cold Storage*, National Agricultural Statistics Service.