Are Hedonic Second-Stage Characteristic Demand Reflective of Actual Characteristic Demands?

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Employing characteristic demand modeling theory to derive input characteristic values, we used these values to estimate characteristic demand models and compare results from this procedure (indirect) to characteristic demand model results using a direct procedure. We model wheat protein because of the extensive previously research on valuing wheat protein and the availability of data to estimate direct protein demand models. Our results indicate concern in using indirect generated data to estimate factors affecting the demand for characteristics. In particular, we find that the magnitude of difference between the direct and indirect estimated flexibilities for wheat protein differs by around a factor of forty.

keywords: wheat protein, hedonic modeling, Rosen methodology

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Food and commodity characteristic demand issues are of growing importance to U.S. agriculture. Consumer demands for foods that improve their health and lifestyles, identity preservation of crops for animal and human consumption, and rapid changes in the ability to supply a bundle of characteristics using biotechnology advancements are but a few of the reasons for this increasing concern. The question of 'if' it can be done is rapidly being replaced with 'should' it be done. Aside from some perhaps moral or ethical issues, economics stands at the heart of this latter question. Assessing which characteristics, and how much value can be created from enhancing a characteristic, are of importance. Characteristic demand models, i.e., hedonic models, offer the potential to assess these questions. Understanding factors affecting characteristic values is also of importance. Yet, little is know about how results garnered from characteristic demand modeling represent direct characteristic supply-demand estimation results.

Rosen (1974) showed using a simple one characteristic theoretic model how equilibrium in the market for this product characteristic was obtained. His approach is widely recognized as the proper theoretic framework from which to build empirical models to attain parameters that define the demand and supply for product characteristics. Unfortunately, Rosen's two-stage model has not often been applied, and it is not entirely clear how such applications should proceed across various situations (Mendelsohn 1984a, 1984b, 1987; Brown and Rosen; Epple; Lang and Kahn). Further, extremely limited data for commodity characteristics, at least to this point, has made it difficult to replicate the Rosen model in any setting. Without such opportunities, we are left to weigh the accuracy of characteristic demand models on the specifics of each study.

In addition to questioning Rosen's empirical guidelines, Brown and Harvey Rosen (1982) believed estimated marginal implicit characteristic prices would differ from collected prices, if such a price series existed, in second-stage analysis. Our proposed research will address this critic because we statistically analyze the indirect estimated marginal implicit prices and direct estimated collected prices

We propose to formally evaluate the Rosen model. Our attention is on wheat protein, which is arguably the most important characteristic that differentiates hard wheat for various end-uses (Stiegert and Blanc). Specifically, we plan to compare the first-stage hedonic results of a two-region model (Parcell and Stiegert) to a simultaneous system of flexible demand equations for wheat protein in the HRW and HRS regions of the U.S. (Stiegert and Balzer). We obtain parameter estimates for the demand for wheat protein that can be compared to a conventional supply and demand model estimate of the protein market derived from protein premium market data.

Review of Rosen Methodology and Application

Rosen's (1974) theoretical analysis titled, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," provided the theoretical foundation for the estimation procedures of structural supply and demand equations for product characteristics. Rosen developed a simple one characteristic model and showed how equilibrium in the market for this characteristic was obtained. Rosen postulated that the marginal implicit pricing schedule for a characteristic is a series of equilibrium between supply of and demand for the characteristic over time or between markets. Figure 1 graphically depicts this situation. According to Rosen, some may inappropriately interpret the dashed line in Figure 1, drawn through the equilibrium points representing the marginal implicit values estimated from the standard hedonic pricing equation, as the demand function for that characteristic. However, Rosen argued that those points are just a sequence of supply and demand equilibrium that shift due to changes in exogenous supply and demand factors.

Rosen showed that first-stage hedonic modeling overlooks changing marginal implicit values for different levels of characteristics because only consumer behavior is considered, while producer behavior is overlooked. He rationalized that supply of characteristics and demand for characteristics at any given characteristic level creates the marginal implicit value schedule for a characteristic. Rosen concluded, "In fact, those [estimated first-stage hedonic price-characteristics] observations were described by a joint-envelope function and cannot by themselves identify the structure of consumer preferences and producer technologies that generate them" (p. 54).

Rosen suggested a two-step procedure to estimate characteristic supply and demand equations. First, traditional hedonic modeling is used to estimate marginal implicit values. Next, marginal implicit prices computed from the estimates become endogenous variables in the second-stage simultaneous estimation of structural supply and demand equations. Assume the price of good *k* can be specified as $p_k(z)$, where *z* is a 1 x *i* vector of characteristics of good *k*. The hedonic function for good *k* is a regression of the form (Lucas and Brorsen, Grant, and Rister):

(1) $$p_k = p(z_{k1}, \ldots, z_{ki}; u_k),$$

where u_k is a white noise, normally distributed, error vector. A series of marginal implicit values for characteristic *i*,

(2) $$\partial p_k(z)/\partial z_{ki} = P_{ki}(z),$$

can be computed from estimation of (1) and used as a price vector for characteristic *i* in the second-stage supply and demand equations to be estimated:

(3) $$P_{ki}(z) = F_{ki}(z_i, Y_1) \quad \text{(demand)}$$

(4) $$P_{ki}(z) = G_{ki}(z_i, Y_2) \quad \text{(supply)},$$

where F_{ki} and G_{ki} represent functions of demand for z_i and the supply of z_i, respectively, and Y_1 and Y_2 represent a vector or exogenous shift variables of demand and supply. Rosen suggested estimating the specified structural supply and demand equations specified in equations (3) and (4) independently using Ordinary Least Squares.

Mendelsohn (1987) contradicted Rosen suggestions that the simple linear model approach for the estimation of structural equations was sufficient. He suggested that by virtue of his earlier research (1984b) the bias in structural demand coefficients may be corrected with two-stage least squares. Mendelsohn refuted earlier assumptions of an exogenous supply schedule as a solution to identification problems of demand functions. He suggested single-market data was acceptable if the proper nonlinear functional form was modeled in the first-stage hedonic analysis. Mendelsohn stated that when marginal implicit prices are held constant, a first-stage analysis will capture all marketing and production effects, e.g., structural demand variables. Coefficients estimated using nonlinear functional form allow for a non-constant marginal implicit price gradient. Thus, a nonlinear functional form will never capture all structural effects in first-stage hedonic estimates and allows for the estimation of structural demand estimates in second stage analysis. Mendelsohn cautioned that linear models of second-stage coefficients were consistent only if a proper nonlinear first-stage functional form was chosen.

Also in 1987 Epple commented on Rosen's research. Epple concluded that the technique for correction of estimation error was through collection of multiple location data sets. He stated, "The form of the demand and supply functions depends on the tastes of consumers with a given set of characteristics or on the technology of producers . . . Therefore, the parameters of these demand and supply functions should not vary across markets." (p. 66). Epple suggested allowing supply to be exogenous in the second-stage estimation model. However, Epple was referring to immobile assets, e.g., houses, and not mobile assets, e.g., agricultural commodities, that can flow between geographic boundaries. Production of agriculture commodities, especially crops, asserts supply is fixed during a production period. Furthermore, Epple's hypothesis that parameter estimates vary across location is not applicable to the case of agriculture commodities to the extent that the commodities are only geographically separated and not heterogeneous.

Bowman and Ethridge were the first to apply second-stage hedonic analysis to an agricultural commodity. They examined U.S. regional cotton characteristic data for the cropping years 1976-1977 to 1986-1987 to evaluate the structural demand and supply of individual characteristics. All observed prices and quality characteristics were evaluated relative to a base set of quality attributes and a base price. This procedure allowed for the capture of overall market movements. Cotton characteristics evaluated included trash content, color, length of fiber, low micronaire, high micronaire, and strength.

Although Bowman and Ethridge did not follow the Rosen approach explicitly in obtaining first-stage parameter estimates, their procedure alleviated the necessary condition of non-linear functional form suggested by Mendelsohn (1984b, 1987) and Epple. Using a linear functional form they estimated coefficients based on yearly observations. This procedure produced multiple data points for each characteristic's marginal implicit value, by region. Thus, a non-constant marginal implicit value schedule was derived for each characteristic. Estimated marginal implicit values were then used as dependent variables in the estimation of structural demand and supply equations.

Chiou et al. estimated first and second-stage hedonic models to evaluate the economic benefits of biotechnology on cotton. In the first stage Chiou et al. estimated four separate models, for four different locations, for different cotton characteristics. Similar to Bowman and Ethridge, Chiou et al. computed the marginal implicit prices across the different locations so that it was not necessary to specify the impact of a change in quality on price using a nonlinear functional form. The series' of marginal implicit prices for staple and strength estimates from the first stage model were used in the second stage estimation of characteristic supply and demand equations for cotton staple and strength.

Using what has been learned from previous characteristic demand research, we apply Rosen's theoretical model to a wheat characteristic, protein, to estimate the demand flexibilty and we compare this estimate to a set of directly estimated demand flexibilities.

Empirical Models

Empirical studies explaining the impact of commodity quality attributes on commodity price are now over 70 years old, e.g., Waugh (1929). Court (1939) first introduced the word "hedonic" to the literature in describing the impact of automobile characteristics on price paid by consumers.[1] The theoretical underpinnings of linking consumer theory to the derivation of characteristic demand models is credited to Lancaster. However, Ladd and Martin's methodological link of characteristic demand analysis and neoclassical firm theory contributed significantly to the use of hedonic modeling in the agricultural economics literature. Ladd and Martin showed the price of a good equals the sum of the implicit value of the input's characteristics and demand for the input is affected by the quantity of the input's characteristics.

First-Stage Indirect Specification of Characteristic Price-Demand Relationships

Parcell and Stiegert expanded on the standard Ladd and Martin framework by modeling price as being determined by aggregate characteristic levels as well as local characteristic levels. Parcell and Stiegert estimated a characteristic demand model for Hard Red Winter (HRW) and Hard Red Spring (HRS) wheat. The first-stage hedonic model developed by Parcell and Stiegert is used in the present study to obtain a protein price series for use in the estimation of structural demand equations for protein. The characteristic demand equations estimated by Parcell and Stiegert were of the form:

(5) Kansas HRW District Price = *k*(HRW Own District Protein Level , Interaction term between HRW Own District Protein Level and Regional HRW Production Weighted Protein Level, Interaction term between HRW Own District Protein Level and North Dakota HRS Base Protein Level, $\mathbf{X}_K$)

(6) North Dakota HRS District Price = *n*(HRS Own District Protein Level , Interaction term between HRS Own District Protein Level and Regional HRS Production Weighted Protein Level, Interaction term between HRS Own District Protein Level and Kansas HRW Base Protein Level, $\mathbf{X}_{ND}$)

Because the interest of this study is on protein, discussion of other wheat quality characteristics is forgone ($\mathbf{X}_K$ and $\mathbf{X}_{ND}$). For a complete specification and description of variables used in equations (5) and (6) see Parcell and Stiegert. Three terms of interest in each equation are the district protein average, the interaction of district average and the average of all other districts within each region, and the interaction of district average protein with the annual protein level in the other region.

Mendelsohn (1984a, 1984b) and Lang and Kahn are among the many researchers who have suggested the need for a non-linear functional form in first-stage hedonic analysis when

[1] Court credited Alexander Sachs with first suggesting the term "hedonic." And, Court, referring to the shortened term hedonic from hedonism, stated (p. 107), "Hedonic price comparisons are those which recognize the potential contribution of any commodity, a motor car in this instance, to the welfare and happiness of its purchasers and the community."

estimating second-stage characteristic demand equations from first-stage marginal implicit values. Mendelsohn (1984b, 1987) and Kahn and Lang suggested a non-linear functional form must be used in the first-stage estimation so that the marginal implicit price changes as the level of characteristic changes. If equations (5) and (6) are estimated using a linear functional form, the marginal implicit values will be constant and independent of the quantity of characteristic (Witte, Sumka, and Erekson). Because the value of the protein characteristic in the current study involves interaction terms, i.e., non-linear specification in protein, the marginal value of protein is calculated as:

$$(7)\quad \frac{\partial\ (District\ Wheat\ \mathrm{Pr}ice)_{it}}{\partial (District\ Protein\ Level)_{it}} = \hat{\beta}_1 + \hat{\beta}_2 Production\ Weighted\ Protein\ in\ Own\ Region_{it} + \hat{\beta}_3 \mathrm{Pr}otein\ Level\ in\ Other\ \mathrm{Re}gion_t = District\ \mathrm{Pr}otein\ Premium_{it},$$

where subscript i refers to the ith reporting district in either Kansas or North Dakota (i=1, ..., 9), and subscript t refers to time period (t=1, ..., 23; 1974-1996). 207 observations were used in the estimation of derivation of the implicit protein premium, i.e., data were pooled across nine district and 23 time periods. The first term represents the level of protein in all other districts within the region and the second term represents the annual average protein of level in the other region. Because the value of the protein characteristic involves interaction terms, the marginal implicit pricing schedule for the protein characteristic derived using (7) is now a 207 x 1 vector or protein prices ($District\ Protein\ Premium_{it}$) that changes as the level of own and competing region characteristic levels change. The price gradient is used as the dependent variable series in the estimation of a protein structural demand equation in the second-stage hedonic analysis. The $\hat{\beta}$'s represent estimated coefficients from the first stage hedonic model. Parcell and Stiegert estimated $\hat{\beta}$'s (cents/bushel) for the characteristic demand HRW wheat price model as 0.218, -0.006, and -0.004, and for the characteristic demand HRS wheat model they estimated the $\hat{\beta}$'s as 0.169, -0.002, and -0.007.

Brown and Rosen stated, ". . . marginal prices constructed only from quantities do not in themselves add any information to that already provided by observations on quantities" (p. 767). Thus, by modeling protein in the first-stage analysis as a function of exogenous factors, own district protein quantity need not be treated as an endogenous variable in the second stage.

Second-Stage Indirect Specification of Protein Price-Demand Relationships

Using Rosen's concept that the marginal implicit pricing equation is a dynamic equilibrium of supply and demand factors, the current study proposes an empirical model to estimate the impact of characteristic demand factors for HRW and HRS wheat protein premiums. Whereas Mendelsohn suggested that supply need not be exogenous, he was not considering agricultural commodities but rather goods, such as houses, for which the supply of specific characteristics could be created or withheld from the market. However, farmers have limited ability to change the level of protein produced or withhold the supply of protein from the market through storage. Therefore, for this analysis the supply of HRW and HRS protein is assumed exogenous.

Following from Rosen's methodology, the protein prices (dependent variables) used for second-stage estimation of the protein inverse demand models are the marginal implicit prices calculated using (7). Assuming supply exogenous, it is then possible to specify inverse demand models to quantify the impact on protein price caused by changes in demand shifters.

The inverse demand models estimated for HRW and HRS wheat protein premium ($\_PTP_{it}$) in Kansas or North Dakota district *i* in year *t* were:

(8) $$KPTP_{it} = \gamma_0 + \gamma_1 KPT_{it} + \gamma_2 KPTORRATIO + \gamma_3 KPRODRATIO_t + \gamma_4 QGLUTEN_t + \varepsilon_t^K$$

(9) $$NPTP_{it} = \phi + \phi_1 NPT_{it} + \phi_2 NPTORRATIO + \phi_3 NPRODRATIO_t + \phi_4 QGLUTEN_t + \varepsilon_t^{ND}$$

Variable definitions are given in table 1. The inverse demand models specified in equations (8)and (9) state that Kansas HRW and North Dakota HRS protein premium is a function the district average protein level ($\_PT$), the average other region's protein relative to the average own regions's protein ($\_PTORRATIO$), the ratio of annual wheat production in own region to other region ($\_PRODRATIO$), and quantity of gluten in the U.S. (*QGLUTEN*). The model specification was chosen based on theoretical grounds, while giving way to bias toward the specification presented in the direct model estimate by Stiegert and Balzar.

Direct Specification of Protein Price-Demand Relationships

Following Stiegert and Balzar, the inverse demand equations – assuming supply exogenous – for intrinsic protein premiums are given by:

(10) $$\text{phrw}_t = c_0 + c_1 * \text{qhrw}_t + c_2 * \text{qhrs}_t + c_3 * \text{qws}_t + c_4 * \text{D}_{g,t}$$

(11) $$\text{phrs}_t = d_0 + d_1 * \text{qhrs}_t + d_2 * \text{qhrw}_t + d_3 * \text{qws}_t + d_4 * \text{D}_{g,t}$$

The dependent variables are specified as the ratio of price of high protein wheat to the price of low protein in the respective region. The term phrw is the price ratio of HRW 13.5% wheat to 11.5% wheat. The term phrw is the price ratio of HRS 14.5% wheat to 13.5% wheat. The term qhrw is a quantity ratio of high protein (wheat containing 12% protein or higher) HRW over the quantity of low protein (below 12%) HRW wheat harvested. Similarly, the term qhrs is defined as a high protein to low protein quantity ratio, but with a break-point of 14% protein. The coefficients c1 and d1 represent inverse demand slopes, i.e., flexibilities, for wheat protein price ratios.

The variable qws represents the ratio of the HRW production to HRS production. HRW wheat production accounts for over 2/3rds of total hard wheat production. When the HRW wheat crop is large, ceteris parabis, then protein is simply less scarce because of the larger quantities of wheat in the 12-14% protein range.

Data

Summary statistics of the data for second-stage hedonic estimation and direct estimation are reported in table 2. For the indirect approach, data were annual, by location, from 1974 to 1996. See Parcell and Stiegert for a detailed description of data used for estimation of the HRW and HRS wheat characteristic demand models. The data used for the Stiegert and Balzar directed estimated price-quantity relationships covers the 1974 to 1997 period. See Stiegert and Balzar for a detailed description of data used for estimation of the direct estimated price-quantity relationship.

Results

The indirect second-stage data were corrected for autocorrelation and heteroskedasticity following procedures outlined by Parcell and Steigert. Data used to estimate the direct models were estimated as a system of equations following the procedures outline by Stiegert and Balzar. All models were estimated in SHAZAM 9.0.

Both the indirect and direct models were estimated using a linear functional form. Thus, coefficient estimates are the size of the effect on the dependent variable in $/bushel. Model results are presented in tables 3 and 4 for the indirect and direct models, respectively. Own-protein quantity flexibilities, computed at the mean, are reported in table 5.

The flexibilities computed at the means for the indirect and direct models differ considerably in magnitude. The direct estimate yields flexibilities at the mean that is nearly perfectly elastic. The indirect estimate yields flexibilities at the mean that are elastic but roughly a magnitude of 36 to 45 lower than the elasticity arrived at using the direct model.[2] On the surface, there appears to be little similarity between the direct and indirect derived own-characteristic flexibilities.

In order to test whether the point flexibilities between the indirect and direct approach are similar, flexibilities in both studies were used to estimate the following model

$$\text{(12)} \qquad \text{Direct Flexibility Estimate}_t = \lambda_0 + \lambda_1 \text{ Indirect Flexibility Estimate}_t \ ,$$

where the null-hypotheses of $\lambda_0 = 0$ and $\lambda_1 = 1$ are jointly tested. The test of $\lambda_0 = 0$ is a test of scaling between the estimated flexibilities, and the test of $\lambda_1 = 1$ is a test of consistency between the two series. Because the direct model yields twenty-four flexibilities over time and the

[2] Note, the elasticity lower bound is computed as the reciprocal of the computed flexibility.

indirect model yields 201 flexibilities over time and across locations, models following from (12) were estimated for each district in Kansas and North Dakota after dropping the computed flexibility for 1997 in the direct model. Thus, eighteen equations were estimated using twenty-three observations in each equation, i.e., data from 1974 to 1996.

Using equation (12) we tested whether the difference between the direct and indirect derived own-characteristic flexibilities were linked by scaling or consistency. For the HRW own-protein quantity characteristic flexibility there was minimal evidence of a scaling difference and no evidence of a consistency difference. For the HRS own-protein quantity characteristic flexibility there was neither evidence of a scaling or consistency difference between the direct and indirect derived flexibilities.

Implications for Characteristic Demand Modeling

Employing characteristic demand modeling theory to derive input characteristic values, we used these values to estimate characteristic demand models and compare results from this procedure (indirect) to characteristic demand model results using a direct procedure. We model wheat protein because of the extensive previous research on valuing wheat protein and the availability of data to estimate direct protein demand models. The importance of understanding how well indirect modeling procedures yield data and information that represents actual data and information is important. As the demand of characteristics changes with genetic research and biotechnology it will be pertinent to understand which characteristic to enhance and how enhancing these characteristics will impact the value of the characteristic.

Our results indicate concern in using indirect generated data to estimate factors affecting the demand for characteristics. In particular, we find that the magnitude of difference between the direct and indirect estimated flexibilities for wheat protein differs by around a factor of forty. While we acknowledge difficulty in generating data and model specification in replication between the indirect and direct methods, such a large difference suggests indirect results should be used with caution.

Following on Rosen's theory that first-stage hedonic characteristic marginal implicit prices only represent points in the price-quantity space where supply and demand intersect so that this marginal implicit pricing schedule can be used to estimated specific characteristic supply-demand equations, considerable research has been conducted on proper specification of characteristic supply-demand models (second-stage) derived from the pricing series generated from first-stage results. Yet, no one has tested the validity of these procedures against a direct estimated characteristic supply-demand models due to data limitations. We find credence in further investigation of the research to date, particularly that research used to arrive at policy implications using the two-stage characteristic supply and demand modeling originally introduced by Rosen.

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Table 1. Description of Variables Employed in Empirical Models

Variable name	Definition
Indirect Implicit Protein Price-Quantity Model	
$KPTP_{it}$, $NDPTP_{it}$	Protein premium in district *i* (*i* = 1, . . ., 9) at time *t* (t= 1974, . . ., 1996) estimated from first-stage hedonic model reported in Parcell and Stiegert ($/bushel).
$KDPT_{it}$, $NDDPT_{it}$	District protein (%/bu) in year *t*.
$KPROD_{t}$, $NDPROD_{t}$	Ratio of own region's total production of protein (production multiplied by average protein content in the region) to other region's total production of protein in year *t*.
$KPRODRATIO_{t}$, $NDPRODRATIO_{t}$	Ratio of other region's protein level to own region's protein level in year *t*.
$Qgluten_{t}$	Domestic gluten production plus gluten imports (000 tons) in year *t*.
Direct Implicit Protein Price-Quantity Model	
phrw_t	HRW protein price ratio: (Kansas City 13.5%)/(Kansas City 11.5%) in yeat *t*.
phrs_t	HRS protein price ratio: (Minneapolis 14.5%)/(Minneapolis 13.5%) in yeat *t*.
qhrw_t	HRW quantity ratio (>12% protein wheat)/(<12% protein wheat) in yeat *t*.
qhrs_t	HRS quantity ratio (>14% protein wheat)/(<14%protein wheat) in yeat *t*.
qws_t	HRW production ratio (HRW wheat production) / (HRS wheat production) in yeat *t*.
Dg_t	Domestic gluten production plus gluten imports (000 tons) in yeat *t*.

Table 2. Summary Statistics of Selected Wheat Characteristics (1974-1996).

Characteristic	Average	S.D.	Minimum	Maximum
Indirect Implicit Protein Price-Quantity Model				
HRW district protein (%/bu)	12.03	0.58	10.60	14.80
HRW regional average protein (%/bu)	12.06	0.40	11.20	13.40
Production (000 bushels)	367610	69615	213600	472000
Protein premium ($/bushel)	0.085	0.006	0.068	0.098
HRS Protein (%/bu)	14.34	0.62	12.60	17.20
HRS regional average protein (%/bu)	14.76	0.78	13.80	16.50
Domestic gluten quantity	17.76	7.08	7.85	30.75
Direct Implicit Protein Price-Quantity Model				
phrw	1.06	0.06	1.01	1.18
phrs	1.05	0.05	0.99	1.26
qhrw	3.29	6.318	0.20	29.33
qhrs	3.01	6.35	0.47	31.45
qws	2.49	0.83	1.20	4.87
Dg	17.76	7.08	7.85	30.75

Table 3. Indirect Implicit Protein Price-Quantity Model Estimation Results.

Hard Red Winter Protein			Dark Northern Spring Protein		
Characteristic	Parameter Estimate	*t-stat.*	Characteristic	Parameter Estimate	*s.e.*
Own-quantity district protein	-0.34E-02 (***)	8.76	Own-quantity district protein	-0.22E-02 (***)	9.82
Ratio of HRS protein level to HRW protein level	-0.042 (***)	11.98	Ratio of HRW protein level to HRS protein level	-0.056 (***)	14.59
Ratio of HRW wheat production to HRS wheat production.	-0.37E-02	11.90	Ratio of HRS wheat production to HRW wheat production.	-0.19E-02	2.05
Gluten quantity	-0.98E-04 (***)	7.82	Gluten quantity	-0.27E-04 (***)	2.11
Constant	0.193 (***)	25.73	Constant	0.141 (***)	29.07
R-*squared*	0.691		R-*squared*	0.663	
No. of observations	207		No. of observations	207	

Note: Three asterisks (***) denote coefficients significantly different from zero at the 0.01 level.

Table 4. Direct Implicit Protein Price-Quantity Model Estimation Results.

Variable	Coefficient	Estimate	*t-stat*
	Price-dependent HRW Equation		
Intercept	c0	12.4600	32.5040 *
qhrw	c1	-0.0422	-2.5030 *
qhrs	c2	0.3497	2.0332 *
qws	c3	-0.5976	-12.9940 *
D_g	c4	0.0264	-1.5010
R^2	0.9323		
	Price-dependent HRS Equation		
Intercept	d0	9.2703	31.1700 *
qhrs	d1	-0.0429	-3.1290 *
qhrw	d2	-0.0425	-3.2060 *
qws	d3	0.2006	5.6105 *
D_g	d4	0.0607	4.4446 *
R^2	0.5948		

* denotes significance at the 5% level

Table 5. Protein Own-Quanity Flexibilites Computed at the Means.

Hard Red Winter Protein		Dark Northern Spring Protein	
Indirect Implicit Protein Price-Quantity Model			
Protein Own-quantity	-0.4783	Protein Own-Quantity	-0.5748
Direct Implicit Protein Price-Quantity Model			
Protein Own-quantity	-0.0128	Protein Own-Quantity	-0.0123

Figure 1. Hedonic Pricing Equation Derived via Equilibrium between Supply of and Demand for Quality factor Z_i.