MISSPECIFICATION IN SIMULTANEOUS SYSTEMS: AN ALTERNATIVE TEST AND ITS APPLICATION TO A MODEL OF THE SHRIMP MARKET

J. D. Lea and J. S. Shonkwiler

Abstract

Concern over the effects of public policies based on misspecified econometric models motivates interest in a procedure to test, diagnose, and improve the specification of models that have been estimated with three-stage least squares. A test of system-wide specification based on Hausman's specification test is employed in a test of the *a priori* restrictions placed on the parameters of a structural model of the U.S. shrimp market. The null hypothesis of proper specification is rejected. After diagnosis via a comparison of unrestricted and restricted reduced forms and respecification, the null hypothesis cannot be rejected.

Key words: misspecification test, econometric models, reduced forms, policy, shrimp.

Judge et al. assert "that the possibilities for model misspecification are numerous and false statistical models are most likely the rule rather than the exception" (p. 854). Are the policies derived from such models equally flawed? A concern for the impacts policy can have on societal welfare suggests that the appropriate action to take is to test the specification of models that might likely be relied on for policy purposes. The purpose of such a test would be to either add to the creditability of the existing model or to use the information contained in that model and the information gained from the testing process in an effort to produce a more accurately specified model. The policy implications of the respecified model can then be compared to those of the pre-existing model to assess the need for changes in policy.

Such a procedure of econometric model specification, testing, and respecification may be applicable to the development of most structural econometric models. Certainly such a procedure is applicable in modeling circumstances like those occurring in the United States (U.S.) shrimp market. Changing shrimp import levels foreshadow increased demand for policy changes in the face of uncertainty relating to fundamental market relationships. Adoption of recently improved shrimp farming techniques by several Central and South American countries has led to significant increases of shrimp imports into the U.S. market. It is anticipated that the U.S. shrimp production sector will request policy changes to assist their adjustment to the changed market conditions.

Currently, there is considerable disagreement among economists relating to fundamental market parameters such as the income elasticity of demand and the price elasticity of demand. These differences translate into substantially different policy recommendations for the same policy goal. For example, Prochaska and Keithly conclude that "fishermen's prices probably will not be driven further downward from current levels" in response to the increased imports because income growth in the U.S. and a high income elasticity of demand for shrimp will result in demand shifts sufficient to offset the price depressing effect of the increased imports (p. 3). The results reported by Thompson et al. predict the

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opposite result due to an income elasticity of demand in the inelastic range (p. 14).

Under the circumstances of developing policy based on existing models or developing a new or respecified model, a test of the system-wide specification of the model in question may be of use to applied researchers. Such a test would be particularly applicable when three-stage least squares (3SLS) estimation is the selected procedure. The value of an econometric model which has been estimated by 3SLS techniques is largely dependent on appropriate system-wide specification since it is well known that misspecification of even a single equation can contaminate parameters in other equations (Judge et al., p. 617; Hausman). The value of such a test would be enhanced if the researcher could expect to gain some insight into the changes required to improve the existing model specification.

We propose a test of system-wide specification that parallels full information tests of over-identifying restrictions (Byron) but which can be used to analyze models estimated with 3SLS. The test is based on Hausman's specification test but is to be distinguished from the structural simultaneous equations specification test Hausman presents in his paper. Our focus on the 3SLS estimator rather than the full information maximum likelihood (FIML) estimator reflects an assumption that the 3SLS estimator is the more widely used of the two. This preference may be based on the availability of computer programs for estimating the 3SLS estimator and on the difficulty occasionally experienced in achieving convergence in computer programs used to estimate the FIML estimator.

Our choice of the Hausman-type misspecification test, rather than employing non-nested tests of hypotheses, reflects our interest in testing existing models in the absence of clearly specified alternatives. As pointed out by Hausman, "a main stumbling block to specification tests has been a lack of precisely specified alternative hypotheses" (p. 1252). Kennedy distinguishes between specification tests and misspecification tests on the basis of an existing alternative hypothesis; "[specification tests] are constructed with some clear alternative hypothesis in mind whereas [misspecification tests] are not" (pp. 67-68).

The specification diagnostic alluded to earlier involves a comparison of the restricted and unrestricted reduced forms of the model. This diagnostic is motivated by the suggestion of Zellner and Palm to use the information provided by final and reduced forms of the structural model in an iterative process to develop "a model that is reasonably in accord with the information in the sample data" (p. 17). For another example of the use of this type of diagnostic see Wohlgenant.

The purpose of this paper is to demonstrate a misspecification test and an accompanying specification diagnostic that can be used in conjunction with 3SLS estimation procedures. The testing approach is motivated in the next section and is then applied to a dynamic, econometric model of the U.S. shrimp market. The use of the specification diagnostic is then illustrated, and a summary of the findings is presented in the concluding section of the paper.

SPECIFYING AND TESTING SIMULTANEOUS SYSTEMS

Consider a system of simultaneous equations represented by

$$(1) \qquad Y\Gamma + X\Delta + E = Z\beta + E = O,$$

where Y and E are t x g matrices of endogenous variables and structural disturbances, respectively; X is a t x k matrix of predetermined variables; and Δ and Γ are parameter matrices of dimensions k x g and g x g, respectively. The matrix Z is composed of the Y and X matrices concatenated horizontally, and the matrix β is composed of the Γ and Δ matrices concatenated vertically. The implied, restricted reduced form generated by the system is

$$(2) \qquad Y = -X\Delta\Gamma^{-1} - E\Gamma^{-1} = X\pi + V,$$

where $\pi = -\Delta\Gamma^{-1}$ and $V = -E\Gamma^{-1}$, respectively.

Specification entails the imposition of restrictions which reduces the number of nonzero elements of the structural parameter matrices. A test of over-identifying restrictions can be accomplished via a likelihood ratio test of FIML estimates of the restricted and unrestricted reduced forms of the model. However, the likelihood ratio test is inappropriate when only the 3SLS estimator of the restricted form is available.

If the 3SLS parameter values, which are asymptotically equivalent to the FIML parameter values, were used to calculate the likelihood of the restricted reduced form, the likelihood ratio test would tend to over-reject the hypothesis of no misspecification because the computed likelihood of the 3SLS model will always be less than or equal to the likelihood of the FIML estimator (the restricted estimator) in small samples.[1] Thus, when only the 3SLS estimator is available, the likelihood ratio cannot be used to assess the validity of the over-identifying restrictions. An alternative test of structural specification can be obtained by employing a Hausman-type misspecification test.

The Hausman Test

The basic requirement of the Hausman test is the existence of two estimators: one that is efficient under the null hypothesis of no misspecification and another that is consistent under both the null and alternative hypotheses. Under the alternative hypothesis, the efficient estimator will be asymptotically biased and will differ from the consistent estimator by more than the expected sampling error. In the context of a simultaneous system, let $\pi_3 = -\Delta_3\Gamma_3^{-1}$ denote the restricted reduced form parameter matrix obtained from 3SLS structural parameter estimates. Whenever the system is over-identified, π_3 is efficient relative to the unrestricted least squares estimator, π_{ols}, (Dhrymes) if the structure is correctly specified.

If the over-identified structural system is misspecified, π_{ols} is still a consistent estimator, but π_3 is now inconsistent. Denote the parameter covariance matrices associated with $Vec(\pi_{ols})$ and $Vec(\pi_3)$ by Ω_{ols} and Ω_3. Then a Hausman specification test statistic is

$$m = q' (var(q))^{-1} q,$$

where $q = Vec(\pi_{ols}) - Vec(\pi_3)$ and the variance of q is $var(q) = \Omega_{ols} - \Omega_3$. This test statistic is distributed as chi-square with degrees of freedom equal to the number of elements in q. If the system contains identities, only the reduced form parameters of the behavorial equations would be used since the reduced form parameters (and their variances) of the endogenous variables defined by identities are simply linear combinations of the reduced forms of the behaviorally determined variables.

An obvious condition for the calculation of the m statistic is that var(q) be non-singular. Although this condition poses no problem in the current context, it often may not hold due to linear restrictions among the elements of q. A solution to this problem is proposed by Kramer and Sonnberger.

Again, if the over-identified system is correctly specified, we would expect the elements of q to be small in the metric of $(var(q))^{-1}$. Misspecification of one or more structural equations can affect all elements of π_3 due to 3SLS being a system-wide estimator. Thus, the alternative hypothesis is of a very general nature. One complication of the test is the requirement that the covariances of the restricted reduced form parameters be computed. Schmidt presents a straightforward way of obtaining these (p. 238). If standard errors for any impact, interim, or long-term multipliers are required, the covariance matrix of the restricted reduced form parameters must be computed anyway.

The restricted reduced form parameters, shown in equation (2), are functions of the structural parameters. Following the result established by Rao (p. 385), the asymptotic variance/covariance matrix of the reduced form can be obtained from

$$\text{(3)} \qquad Var\ (\pi_3) = \partial\pi_3/\partial\beta\cdot\psi\cdot\partial\pi_3/\partial\beta,$$

where ψ is the variance/covariance matrix of the structural parameter estimates (the elements of β) derived via 3SLS procedures. Schmidt provides a practical derivation of equation (3) as

$$\text{(4)} \qquad Var\ (\pi_3) = D\ W\ \psi\ W'\ D',$$

where $D=(\Gamma^{-1})'\otimes I_k$; W is a block diagonal matrix with W_i, i= 1, 2, ··· G, given by $W_i=plim(X'X)^{-1}X'(Y_i,X_i)$; and the symbol ⊗ denotes the Kronecker product. The matrices Y_i and X_i are the g_i and k_i endogenous and predetermined regressors appearing in the ith equation. In practice, the g_i columns of the estimated reduced form parameter matrix are used in the first columns of W_i, since $plim(X'X)X'Y_i$ converges to the vector of population parameter values associated with the endogenous variables in the ith reduced form equation. The remainder of the W_ith submatrix is an auxiliary regression of the predetermined variables appearing in equation i on the complete regressor matrix.

The variance of the unrestricted reduced

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[1] This is because 3SLS maximizes $-trace\ \Sigma^{-1}\beta'Z'X(X'X)^{-1}X'Z\beta$, where $\Sigma=\beta'Z'Z\beta/t$ (Gallant and Jorgenson, p. 279); whereas, FIML maximizes $-t/2\log|\Sigma| + t\log|\Gamma| -1/2\ trace\ \Sigma^{-1}\beta'/Z'Z\beta$ (Schmidt, p. 216).

form, Var (π_{ols}), is obtained from a seemingly unrelated (SUR) estimation of the unrestricted reduced form. In this situation where the unrestricted reduced form is a system of equations with identical regressors, the SUR and OLS parameter estimates are equivalent (Fomby et al., p. 159). Using the SUR estimator allows the cross-equation covariances to enter the test. The variance/covariance matrix of the SUR parameters can be represented as

$$\text{(5)} \qquad \mathrm{Var}(\pi_{ols}) = (P' (\Sigma^{-1} \otimes I_k) P)^{-1} = \Sigma \otimes (X'X)^{-1},$$

where $P = (I_g \otimes X)$ and Σ is the error covariance matrix from the OLS estimation of the unrestricted reduced form parameters,

$$\Sigma = [(Y - X(X'X)^{-1}X'Y)'(Y - X(X'X)^{-1}X'Y)]/T.$$

EMPIRICAL APPLICATION

Our focus on the shrimp market is motivated by an on-going research program concerned with assessing the impact on the domestic market of substantially increased supplies of shrimp which may become available from aquacultural operations. Secondly, increasing awareness of the fragility of dynamic, econometric model specification coupled with improved computing capability provide additional motivation for testing the specification of models that may be relied upon in future policy discussions.

The Structural Model

The structural model we tested is a seven-equation, simultaneous equation model of the U.S. shrimp industry based on monthly data from September 1974 through December 1983 (Thompson et al.). The data for re-estimating the model were kindly provided by Dr. Kenneth J. Roberts. The endogenous variables in the model are:

C = consumption--disappearances from wholesale warehouses (thousands of pounds);
Pw = wholesale price of 26-30 count frozen shrimp, New York ($/lb.);
Pe = exvessel price of 26-30 count shrimp, Northern Gulf of Mexico ($/lb.);
S = stocks–end of month cold storage (thousands of pounds);
I = imports (thousands of pounds);
L = landings from U.S. Gulf of Mexico ports (thousands of pounds); and
TR = fishing effort (number of fishing trips by Gulf shrimpers).

The predetermined variables in the model are:

Pw1 = wholesale price, Pw, lagged one month;
Pw2 = wholesale price, Pw, lagged two months;
Pe1 = exvessel price, Pe, lagged one month;
S1 = end of month stocks, lagged one month;
X2 = currency exchange rate between U.S. and Japan (yen/dollar), lagged two months;
Ex = unadjusted retail sales (expenditures) in eating places;
R = prime rate of interest on short-term business loans;
F = diesel fuel price (dollars/gallon);
PR2 = average precipitation in coastal Louisiana (inches), lagged two months;
T2 = average atmospheric temperature in coastal Louisiana (degrees Fahrenheit), lagged two months;
Q_k = quarterly dummy variable for second, third, and fourth quarter of the year (k=2, 3, 4); and
E_j = error terms (j=1, ···, 7).

All equations are linear in the parameters and are shown in functional form as:

C = f(Pw, Ex, Q_2, Q_3, Q_4, E_1),
Pw = f(S1, I, C, Pe, Pe1, Q_2, Q_3, Q_4, E_2),
Pe = f(L, R, Pw, Pw1, Q_2, Q_3, Q_4, E_3),
S = f(S1, L, I, C, E_4),
I = f(Pw2, X2, Q_2, Q_3, Q_4, E_5),
L = f(PR2, T2, TR, Q_2, Q_3, Q_4, E_6), and
TR = f(Pe, F, L, Q_2, Q_3, Q_4, E_7).

Counting the intercepts, there are fourteen predetermined and seven endogenous variables in the model. Each equation is over-identified with the total number of over-identifying restrictions being fifty. In discussing their model, Thompson et al. recognize the difficulty involved in estimating retail level demand using wholesale level data, noting that the first equation does not contain the prices of complementary or substitute products. Significant effects could not be demonstrated in exploratory specifications.

Thompson et al. describe the second equation in their model as a price level equation, noting that the inclusion of current and lagged exvessel prices motivates this designation and assures that wholesale and exvessel prices move together. The dependence of exvessel prices on market conditions at the wholesale level is treated by including current and lagged wholesale price in the exvessel price equation. Because the U.S. and Japan are the major competitors for world supplies of shrimp, Thompson et al. include the rate of exchange between the Japanese yen and the U.S. dollar in the equation explaining imports of shrimp into the U.S. market. Wholesale price lagged two months was selected for inclusion in the imports equation "after considering lags of zero to six months" (Thompson et al., p. 13).

Thompson et al. note that to treat the production response of the industry adequately, it is necessary to include the equation explaining the effort expended in harvesting shrimp. The number of shrimping trips made by industry vessels is selected as the proxy for effort. Thompson et al. explain that due to the existence of externalities in the shrimp fishery, increased effort may or may not increase the amount of shrimp landed. The landings and effort (trips) equations "were included to describe the 'behavior' of the industry in terms of landings and effort, respectively" (Thompson et al., p. 13). Thompson et al. do not explain why fishing effort depends upon landings; however, one explanation may be that the news of increased catches stimulates increased effort through an industry attempt to maximize revenue under the constraints of fixed capacity and harvest season. This changed effort has an effect on landings. Thus, landings and effort are simultaneously determined. The equation explaining landings of shrimp also reflects the influence of environmental factors on the annual shrimp crop/ population. Note that the fuel price variable, designated by the letter F, appears in one equation only (i.e., the effort or trips equation).

Test Results and Discussion

Thompson et al. estimated their structural model with 3SLS. The results obtained by the present authors from a reestimation of the model were not in total agreement with those published by Thompson et al. due to the present authors' uncertainty regarding the exact form of several exogenous variables. However, since the same data were used to construct both the restricted and the unrestricted reduced forms and their associated variances, this discrepancy will not affect our test results. Following the steps outlined in the previous section, the Hausman m statistic was calculated via a program using the MATRIX Procedure of SAS (SAS). The calculated m value was 272.03. Since this statistic exceeds the critical value for a chi-square variable with 98 degrees of freedom at the 99 percent confidence level, the null hypothesis that the model is correctly specified is rejected.

By itself, the Hausman test result is of limited value in discovering possible causes for the rejection of the null hypothesis and in possibly finding avenues for improving the econometric model specification. Some of the desired information can be obtained from a consideration of the two sets of reduced form parameter estimates. A large difference between estimated parameter values coupled with an indication of parameter significance as shown by the associated t-values greater than two signal a possible source of model misspecification. Recall that the unrestricted reduced form estimate is consistent with the true or population reduced form, but is not affected by the selected specification, while the restricted reduced form is so affected. Thus, the two estimates differ, at least asymptotically, due to the selected specification.

To facilitate the comparison of the 3SLS reduced form parameters from the restricted model with the OLS parameter estimates from the unrestricted reduced form, Table 1 presents both sets of parameters along with the t-values for each parameter. Attention is drawn to the fuel price variable, which is designated by the letter F. In six out of seven equations, the OLS estimate is much larger in absolute value than the 3SLS estimate. These results imply that fuel has a substantial effect on all of the endogenous variables with the exception of the fishing trips variable.

A further implication of these results is that the fuel price variable's effect is not communicated to the rest of the restricted reduced form equations. If this result is obtained because the structural model only permits fuel price to enter the trips equation, it may imply that the trips equation is not important in affecting landings and, hence, other endogenous variables. These considerations argue for dropping the trips equation from a respecification of the model and adding the fuel variable in several of the other equations.

TABLE 1. COMPARISON OF RESTRICTED REDUCED FORM PARAMETER ESTIMATES WITH UNRESTRICTED REDUCED FORM PARAMETER ESTIMATES, U.S. SHRIMP INDUSTRY, SEPTEMBER 1974 - DECEMBER 1983

	APPARENT CONSUMPTION EQUATION				WHOLESALE PRICE EQUATION				EXVESSEL PRICE EQUATION				IMPORTS EQUATION			
Variables[b]	Parameters		t-Values		Parameters		t-Values		Parameters		t-Values		Parameters		t-Values	
	RRF[a]	URF[a]	t-RRF	t-URF	RRF	URF	t-RRF	t-URF	RRF	URF	t-RRF	t-URF	RRF	URF	t-RRF	t-URF
C	15931.17	-21872.27	9.59	-2.12	2.13	2.60	3.14	4.21	1.87	2.00	2.88	4.26	7584.98	-16969.66	2.47	-1.92
Q2	2406.30	-463.02	1.81	-0.32	-0.16	-0.10	-1.22	-1.17	-0.16	-0.09	-1.32	-1.41	-958.78	-3334.98	-0.84	-2.67
Q3	6777.71	-3692.81	4.98	-1.62	-0.41	-0.18	-2.74	-1.32	-0.36	-0.17	-2.37	-1.61	1462.16	-4874.43	1.27	-2.50
Q4	6666.45	-155.14	5.04	-0.08	-0.14	-0.00	-1.00	-0.03	-0.10	-0.00	-0.72	-0.04	7483.64	3546.66	6.64	2.07
Ex	1.98	6.08	6.03	6.69	0.00	-0.00	2.48	-1.93	0.00	-0.00	2.28	-1.95	0.00	3.73	0.00	4.79
R	21.43	-55.69	0.94	-0.21	-0.03	-0.02	-1.76	-1.38	-0.05	-0.04	-2.74	-3.08	0.00	-233.30	0.00	-1.05
F	-3.11	-12234.60	-0.42	-2.08	0.00	0.79	0.44	2.25	0.01	0.79	0.44	2.94	0.00	-8162.48	0.00	-1.62
Pe1	-793.60	-1757.61	-1.15	-0.63	1.17	0.44	5.83	2.65	1.03	0.79	3.70	6.27	0.00	1382.22	0.00	0.58
S1	0.01	0.01	1.00	0.31	-0.00	-0.00	-2.36	-3.55	-0.00	-0.00	-2.37	-3.50	0.00	0.00	0.00	0.04
Pw1	-56.31	-817.36	-0.48	-0.34	0.08	0.51	0.53	3.48	0.12	0.14	0.57	1.27	0.00	-1386.32	0.00	-0.67
Pw2	277.75	779.60	1.13	0.46	-0.41	-0.02	-2.72	-0.19	-0.36	-0.05	-2.50	-0.60	2046.29	924.37	6.58	0.64
X2	2.21	69.33	1.07	3.57	-0.00	-0.00	-1.93	-3.33	-0.00	-0.00	-1.90	-3.29	16.25	68.42	1.78	4.11
PR2	-1.00	54.26	-0.54	0.34	0.00	0.00	0.59	0.36	0.00	0.01	0.61	1.77	0.00	56.41	0.00	0.41
T2	1.46	217.61	0.59	2.99	-0.00	-0.00	-0.66	-0.35	-0.00	-0.00	-0.67	-0.54	0.00	86.41	0.00	1.39

	COLD STORAGE EQUATION				LANDINGS EQUATION				FISHING TRIPS EQUATION			
	Parameters		t-Values		Parameters		t-Values		Parameters		t-Values	
Variables	RRF	URF	t-RRF	t-URF	RRF	URF	t-RRF	t-URF	RRF	URF	t-RRF	t-URF
C	-27353.80	-25497.42	-5.08	-2.99	-20957.91	-25404.98	-3.47	-2.84	-58747.00	-47905.72	-3.45	-1.90
Q2	502.80	-431.02	0.30	-0.36	3776.62	4210.54	1.86	3.34	13132.00	15391.67	2.09	4.34
Q3	-2067.62	-1120.76	-0.78	-0.60	1841.08	-3395.27	0.57	-1.73	-3093.84	-11584.34	-0.34	-2.09
Q4	-80.54	541.96	-0.04	0.33	-2206.48	-3913.69	-0.82	-2.26	-8091.91	-9508.49	-1.00	-1.95
Ex	-1.34	-0.38	-4.15	-0.51	0.08	2.53	0.71	3.21	0.38	0.06	0.88	0.03
R	-31.73	134.56	-1.06	0.63	-20.70	161.37	-0.72	0.72	-103.98	388.96	-0.91	0.61
F	-829.51	-4942.58	-0.58	-1.02	-1038.65	-11318.49	-0.58	-2.22	-5216.51	-3481.85	-0.67	-0.24
Pe1	927.49	1650.80	1.32	0.72	457.52	-2687.60	0.73	-1.12	2297.86	337.16	0.94	0.05
S1	0.97	0.95	57.07	25.37	-0.00	-0.02	-0.76	-0.62	-0.02	-0.28	-0.94	-2.54
Pw1	83.37	115.64	0.50	0.06	54.40	335.06	0.45	0.16	273.20	1186.82	0.49	0.20
Pw2	1425.36	177.00	3.42	0.13	-160.13	843.85	-0.72	0.58	-804.24	-2972.05	-0.91	-0.72
X2	11.32	13.20	1.55	0.82	-1.27	2.55	-0.70	0.15	-6.38	-2.73	-0.86	-0.06
PR2	-266.06	-215.47	-1.38	-1.64	-333.14	-275.48	-1.38	-2.00	-830.77	-134.98	-1.36	-0.35
T2	389.93	330.87	4.66	5.52	488.24	521.37	4.64	8.29	1217.56	1341.18	4.06	7.57

[a] RRF=Restricted Reduced Form, URF=Unrestricted Reduced Form.

[b] C=Constant, Q2=Second Quarter Dummy Variable, Q3=Third Quarter Dummy Variable, Q4=Fourth Quarter Dummy Variable, Ex=Expenditures in Commercial Eating Places, R=Interest Rate, F=Fuel Price, Pe1=Exvessel Price Lagged One Period, S1=Cold Storage Holdings Lagged One Period, Pw1=Wholesale Price Lagged One Period, Pw2=Wholesale Price Lagged Two Periods, X2=Yen/Dollar Exchange Rate Lagged Two Periods, PR2=Precipitation Lagged Two Periods, and T2=Temperature Lagged Two Periods.

Another variable associated with significant parameter estimate differences between estimators is "expenditures in eating places," Ex. Since the OLS estimates of the parameter on Ex are often larger than those estimated by the 3SLS estimator, it may be argued that the econometric specification results in the impact of expenditures being underestimated. This result may be especially important in considering the policy implications of the econometric model's estimation of the impact of expenditures on apparent consumption and on imports. The unrestricted model suggests that expenditures may have a much larger impact on consumption and on imports than suggested by the econometric model.

The expenditure variable can be interpreted as a proxy variable for income as noted by Thompson et al. In this interpretation, it can be used to calculate an income elasticity of demand for shrimp. In their article, Thompson et al. calculated the elasticity of demand related to retail expenditures to be in the inelastic range (.42). However, if the unrestricted model is correct in indicating that the econometric model substantially underestimates the impact of expenditures on consumption, then it is possible that the income elasticity of demand for shrimp is in the elastic range. As shown in Table 1, the unrestricted reduced form parameter estimate for expenditure is three times larger than the restricted reduced form estimate. This difference in value is enough to boost the estimated elasticity into the elastic range. The policy implications of one estimate versus the other are substantially different.

Using the information provided by the comparison of reduced forms and some additional, theoretical considerations, the Thompson et al. model was respecified and reestimated with 3SLS techniques. The reestimated model was tested using the misspecification test described above. The hypothesis of no misspecification in the respecified model could not be rejected at conventional levels of significance. Thus, it appears that the specification of the existing model was improved, relative to the modified Hausman criterion, through the suggested process of testing, diagnostic analysis, and respecification. The respecified model and the complete results of the test are reported by Lea.

The policy implications of both the Thompson et al. model and the respecified model are similar. Both indicated that the price elasticity of demand for shrimp at the wholesale level is inelastic. The parameter on the expenditures variable in the respecified model was insignificantly different from zero. Thus, the policy implications of the Thompson et al. model appear to be robust to the misspecification.

A final point is the relation between the reduced form Hausman test developed here and the structural test Hausman presents in his paper. This latter test compares Vec(β_3) and Vec(β_2) where these symbols represent the three- and two-stage least squares structural estimators respectively. Unfortunately, this test has little power if the off diagonal elements of E'E are near zero. Additionally, there is no guarantee that any of the elements of β_2 are consistent if the overidentifying restrictions are incorrect. A test of this type (comparing Vec(β_3) and Vec(β_2)) was run on the Thompson et al. model. The results indicate that the hypothesis of proper specification cannot be rejected at any conventional significance level. The same, unmodified version of the Hausman test was run on the respecified model. The result echoed that obtained with our modified version of the Hausman test. The hypothesis of proper specification cannot be rejected at any conventional significance level. The inconsistency of the two tests is an obvious subject for further research.

CONCLUSIONS

The modified Hausman test demonstrated here provides a practical check of the system-wide specification of a simultaneous equations model (SEM) that has been estimated with 3SLS. The comparison of restricted and unrestricted reduced forms provides indications of possible sources of misspecification. Used together, these two techniques provide another means of discerning the appropriate specification of a SEM. To the extent that the Hausman criterion is an acceptable standard, achieving that standard through the process described here provides an answer to the criticism that SEMs are generally misspecified and increases the likelihood that the policies developed from our models enhance rather than diminish the public welfare.

In the context of the U.S. shrimp market, this study strengthens our confidence that the U.S. shrimp market is characterized by inelastic demand. The implication for the shrimp industry is clear: in the face of inelastic demand, increased supplies will mean reduced prices for domestic and foreign producers.

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