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ELASTICITIES IN INTERNATIONAL TRADE: THEORETICAL AND METHODOLOGICAL ISSUES*

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Economists have devoted considerable attention to the estimation of international trade flows. Not only is there an extensive literature on the specification and estimation of equations describing these flows, but also there is a large literature surveying these studies (see, for example, Cheng (1959), Prais (1962), Kreinin (1967), Taplin (1967), Leamer and Stern (1970), Magee (1975), Stern et.al. (1976), Thompson (1981), Woodland (1982), Goldstein and Khan (1985), and Gardiner and Dixit (1986)).[1] This is hardly surprising for several reasons. First there are wide-ranging positive, as well as normative, uses for estimated trade equations. Positive uses range from testing trade theories to understanding the transmission of economic disturbances across countries, and normative uses include evaluating alternative commercial policies, exchange-rate regimes, and macroeconomic policies.[2] Second, time series data for international transactions have been easy to obtain historically, making empirical trade studies feasible. Somewhat paradoxically, the data rarely have been appropriate for estimating theoretically derived relationships, so that much of the existing work has focused on methods for dealing with errors in variables or omitted variables. Finally, there is wide variation in the estimated parameter values of trade equations. Price and income elasticities of demand and supply for imports and exports vary by commodity, country, and time period. Even when comparisons of estimates are limited to studies of narrowly defined commodities exported by a single country, estimates vary dramatically (see, for example, Gardiner and Dixit (1986)). Hence a major focus of existing surveys has been to catalogue and, to the extent possible, present a consensus of estimated elasticities.

This paper is a survey of recent research on specification, estimation and evaluation of trade elasticities. Since our focus is primarily methodological we do not give a compendium of recent estimates. Given the excellent and comprehensive nature of previous surveys, the marginal benefit of doing so would be small. In addition, we shall argue that any hope of obtaining a consensus of parameter values from trade equations must rely on taking a different approach. The approach involves using (and allowing the reader to use) as much information as is practically possible. There are both theoretical and econometric reasons to pursue such an approach, and we shall focus on studies which clarify them.

Section 2 outlines issues related to the theoretical specification of trade models or equations. We focus on differences in modelling suggested by differences in commodity subsitutability and by whether they are purchased for final consumption or as inputs into a production process. This allows us to emphasize the fact that very different behavioral models can lead to the same estimating equation for trade flows, in which case proper interpretation of parameter estimates calls for estimation of a system of equations. Unfortunately, the bulk of the empirical trade literature reports single estimating equations with only cursory reference to the theoretical structure motivating the equations. Hence, even if estimated parameters were "reliable," it would be difficult to judge the usefulness of the estimates.

Section 3 considers recent advances in econometric techniques appropriate to assessment of a given model as regards its specification and to the choice of competing models. Section 4 gives several examples of the use of several of these techniques in international trade. One example comes from a study of trade aggregated over commodities, and the other considers Japanese demand for wheat imports from the United States. Finally, Section 5 concludes.

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1 Goldstein and Khan (1985) report that by 1957 there were 42 books and articles containing estimates of income and price elasticities of import and export equations. Stern et.al. (1976) provide a bibliography of 130 studies, and Goldstein and Khan's reference list contains 84 studies dated after the comprehensive Stern et.al. review.

2 For examples, the reader is referred to the surveys listed above.

2. Theoretical Specification of Trade Equations

In this section we focus on issues related to the theoretical specification of trade equations, where the term trade equation means the demand or supply equation for either exports or imports. While examples of each of these can be found in the literature, by far the major emphasis has been on demand equations-.[3] The economics literature has focused primarily on import demand functions, while the agricultural economics literature has focused on export demand functions (see, for example, any of the listed surveys of the economics literature and Gardiner and Dixit (1986) regarding the agricultural economics literature).

In order to discuss the different trade equations together, it is useful to think of them in the following context. For any commodity, a country's net trade can be represented by:

$$(1) \qquad e_i = S_i(p_i^s, f_i) - D_i(p_i^d, y_i)$$

where i is a country index, $i = 1,\ldots,m$, p_i^s is a vector of supply prices, f_i is a vector of factor costs (or factor endowments), p_i^d is a vector of consumer prices, and y_i is income. $S_i(\bullet) \gtreqless 0$ denotes net supply by domestic producers and can be derived theoretically from either a technology or cost function (See Woodland (1982) and references therein). $D_i(\bullet)$ denotes domestic consumer demand and can be derived theoretically by constrained utility maximization.

Equation (1) can be used to represent excess supply for either a single commodity or aggregate commodity trade. The economics literature has dealt largely with estimates of aggregate trade, while the agricultural economics literature has focused on more narrowly defined commodities. We shall abstract from whether the commodity of interest is an aggregate, except to note that there is a literature dealing with when aggregation is appropriate (Green (1964), Berndt and Christensen (1973)).

If e_i is positive, country i is a net exporter of the commodity, and equation (1) can be used to describe its export supply. Country i is a net importer of commodities for which e_i is negative, and $(-e_i)$ can be used to represent the demand for imports of these commodities. $\Sigma_i e_i = 0$ in equilibrium for any commodity. Hence, in equilibrium, if country i is a net exporter of a commodity, its export demand can be represented by $\Sigma_{j\neq i} (-e_j)$. If country i is a net importer, it faces export supply given by $\Sigma_{j\neq i} e_j$.

<u>Perfect Substitutes</u>

This is the usual representation of trade equations when imports and exports are perfect substitutes for goods produced and consumed domestically. It has the convenient property of allowing trade elasticities to be calculated from domestic demand and supply elasticities (Yntema (1932), Johnson (1977), Goldstein and Khan (1985)). For example, country i's price elasticity of demand for imports of a commodity can be expressed as

$$(2) \qquad \eta_{im}^d = (S_i/e_i)(d\ln S_i/d\ln p_i) - (D_i/e_i)(d\ln D_i/d\ln p_i).$$

This expression follows from differentiating $(-e_i)$ from (1), where domestic subsidies and taxes are assumed to be zero so that $p_i^s = p_i^d$. Similarly, the price elasticity of demand for country i's exports of a commodity can be expressed as

3 As noted by Haynes and Stone (1983), all but 10 pages of Stern et.al.'s classic (1976) 363 page book is devoted to demand equations.

$$(3)\qquad \eta^{d}_{ix} = \eta^{d}_{jm}$$
$$= (d\ln p_j/d\ln p^{e}_i)[(D_j/e_i)(d\ln D_j/d\ln p_j) - (S_j/e_i)(d\ln S_j/d\ln p_j)],$$

where j is an aggregate of all countries other than i (thus $e_i = -e_j$), p^{e}_i is the export price, and again, internal subsidies and taxes are zero. The first term on the right hand side of (3) is a transmission elasticity showing the impact of a change in i's export price on the price faced by importers in j. While it is typically assumed to be unity, nontariff barriers or specific tariffs will lower its value (Goldstein and Khan (1985), Gardiner and Dixit (1986)).

Similar expressions can be derived for income elasticities of demand and for supply elasticities for imports and exports when goods are perfect substitutes (see Magee (1975)). Hence a researcher may choose to use domestic elasticity estimates to calculate trade elasticities rather than estimate them directly. Examples of studies using this method in agricultural economics are given in Gardiner and Dixit (1986). Its use is limited in obtaining elasticities for manufactures or aggregate trade since comparable estimates of domestic elasticities are rarely available, and these commodity classifications are not considered to be homogeneous.[4]

Outside the agricultural economics literature, empirical studies of trade have tended to adopt an imperfect substitutes framework. An exception to this is Clements' (1980) multisector econometric model of a small, open economy. His model explains production, consumption, and trade of three goods: exportables, importables, and non-traded goods. The net trade equations are similar to (1) with the net supply and demand functions being derived from optimizing behavior of producers and consumers. The model is applied to the United States for the period 1952-71. Implementing such a model is an ambitious task, but the benefit of the approach is that trade elasticities are estimated in a context where their theoretical interpretation is clear. As we discuss below, recent work in imperfect substitutes models has emphasized the need for such an approach.

Imperfect Substitutes

When internationally traded goods are not close substitutes for domestically traded goods, it is conventional to drop the representation of trade equations as the excess between domestic supply and demand.[5] In this case, demand for imports (exports) is typically written as a function of a price vector and income of the appropriate country (regional aggregate).[6] The simplest examples are

$$(4)\qquad D^{m}_i = f(p^{m}_i, p^{o}_i, y_i)$$

4 Studies by Kravis and Lipsey (1978) and Isard (1977) cast doubt on the law of one price, which is one of the implications of the perfect substitutes model. The work of Richardson (1978) and Thursby, Grennes, and Johnson (1986) has similar implications for certain agricultural commodities.

5 For an exception see Gregory's (1971) study of demand pressure and United States imports.

6 See Houthakker and Magee (1969) for an early example of import demand and Thursby and Thursby (1984) and Goldstein and Khan (1985) for more recent examples.

Much of the estimation of export demand has been done in an elasticity of substitution framework. The reader is referred to Goldstein and Khan (1985), Richardson (1973), and Leamer and Stern (1970) for discussion of this concept.

$$(5) \qquad D_i^x = D_j^m = g(p_j^m, p_j^o, y_j)$$

where, again, j is an aggregate of all countries but i, D_i^m and D_i^x denote import and export demand, p_i^m and p_j^m denote the price of imports in i and j (rest of the world), p_i^o and p_j^o denote price indexes for domestically procuced goods in i and j, and y denotes real national income. More often than not, supply is assumed to be infinitely elastic; but several studies have specified export (import) supply as a function of an appropriate price vector and activity or capacity variable.[7]

In the majority of studies, specifications are chosen according to issues related to estimation, with little attention paid to the behavioral models underlying them. The demands specified in (4) and (5) are often presumed to come from utility maximization, but authors rarely state how the exact functions estimated are derived. As a result, functions may actually be inconsistent with the presumed theory. For example, the log-linear form of (4) and (5) is popular because the parameter estimates can be interpreted as elasticities, but it is not derivable from constrained utility maximization. Efforts to correct this deficiency have been made by Gregory (1971), Burgess (1974a, 1974b), and Kohli (1978, 1982). Gregory (1971) derives an equation for the ratio of imports to domestic goods as a function of their relative prices under the assumption that society's preferences can be represented by a CES utility function. The work of Burgess and Kohli has focused on two issues: (i) the appropriateness of separability restrictions implied by typically estimated trade equations[8], and (ii) the derivation of trade equations based on producer rather than consumer behavior.

Both Burgess and Kohli focus on trade equations for intermediate goods. Goods are assumed to be inputs or outputs of the producer sector, and there is no direct consumer demand for traded goods. Hence $D_i(\bullet) = 0$, so that $S_i(\bullet)$ represents import demand or export supply. In this case an import demand function should be derived from a technology or cost function rather than a utility function. The empirical argument for this approach is that trade in intermediate inputs represents the bulk of international trade, and, even when consumer goods are traded, they must go through some processing or retailing before final consumption.

Burgess (1974a, 1974b) derives and estimates two models of import demand in which firms are assumed to hire minimum cost combinations of imported and domestic inputs (capital and labor). In one model (1974a), investment and consumer goods are outputs, and in the other (1974b), a single output is produced. The technology is sufficiently general in both cases to allow a test of separability

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7 Notable studies of export supply are Goldstein and Khan (1978), Haynes and Stone (1983), Clark (1977), Dunlevy (1980), and Kohli (1978).

8 The typical specification of import demand implies that the utility or profit (cost) function from which demand is derived is separable. Illustrative articles in this regard are Winters (1984), Burgess (1974a), and Goldstein and Khan (1980).

In this survey, we have abstracted from issues related to the aggregation of trade equations across supplying or demanding countries. See Armington (1969) and Winters (1984) regarding separability issues in this regard. Also see Grennes, Johnson, and Thursby (1978) and Johnson, Grennes, and Thursby (1979)) for discussion with regard to modelling trade in agricultural commodities.

between imported inputs and domestic factors. This test is important since input separability would imply the popular specification of import demand in (4) is consistent with the cost minimization model of import demand (where prices are interpreted as input prices). U.S. data are used (1929-1969 is the period for (1974a) and 1947-68 for (1974b)), and in both cases, the separability hypothesis is rejected.

Using Canadian data for 1949-72, Kohli (1978) estimates a similar model. He estimates import demand and export supply simultaneously with domestic demand and supply of factors and outputs. A translog technology is assumed so that separability restrictions can be tested rather than assumed.

One of the most illustrative studies in this area is a theoretical one by Kohli (1982). He examines the implications of using different measures of domestic price and activity variables in estimating equations derived from a common structural model. Throughout the analysis, imports and a domestic composite factor are inputs to produce domestic gross output. The derived demand for imports and the domestic factor plus the unit cost of output are simultaneously determined for cases of constant and variable returns to scale. The natural estimating equation in this case would be

$$(6) \qquad D_i^m = h(p_i^m, v_i, q_i)$$

where v_i is the price of the domestic input and q_i is gross domestic output. Kohli shows that other estimating equations can be derived from the same structural model. For example, equation (4) can be derived from his model. The important point is that when (4) is used in lieu of (6) the price elasticity of demand for imports will be different. With constant returns to scale, the import price elasticity from (4) will be $[(\omega - \theta)/(1 - \theta)]$ where θ is the elasticity of substitution between imports and the domestic cosposite factor and ω is expenditure on the domestic factor as a share of expenditure on gross output. The import price elasticity from (6) will be $[(\omega - 1)\theta]$. Since $\omega<1$, the latter expression will always be negative, but the price elasticity from (4) may be positive. This property carries over to the case of variable returns to scale. Thus a positive estimate of price elasticity of demand in this model need not indicate rejection of the model. Thus Kohli's example shows how critical knowledge of the theoretical structure can be in interpreting elasticities.

3. Econometric Specication and Evaluation

In the previous section we focused on trade equations derived from alternative behavioral models. It is clear that different elasticity estimates may occur in the literature because of differences in behavioral models assumed. It is also clear that the same behavioral model can yield radically different elasticity values when different measures of variables are used. In the latter case, different estimates do not indicate rejection of a model, but call for care in interpretation. The tricky issue is when differences in elasticity estimates should make a researcher suspicious of a model (or class of models).

While the theory gives some quidance in this regard, it does not give a researcher sufficient tools to choose among alternative empirical estimates. Consider, for example, the intermediate goods model of Kohli (1982). Whether one estimates equation (4) or (6), the theory does not indicate the precise form of functions f or h, nor does it suggest whether lagged values should be included. While the theory can indicate how to interprete elasticity values in the two cases [i.e. (4) and (6)], it does not address issues related to errors in measurement of variables. Nor does theory give sufficient quidance on the appropriate procedure when data availability (or ignorance of the researcher specifying the model) leads to omission of an important variable. In this section we focus on the econometric literature dealing with such issues.

Dating at least to the classic works of Theil (1957) and Griliches (1957), economists have been aware of the deleterious effects of misspecification of regression models due to omission of relevant explanatory variables, use of an incorrect functional form, dependence between regressors and disturbances, etc.[9] Much of the attention to specification error has involved tests of whether observed regressors belong in some (presumably otherwise correctly specified) regression; use of simultaneous equation techniques (generally without first testing for the presence of endogeneous regressors); ad hoc techniques such as consideration of sign and significance of regression coefficients and of R^2; etc. At least in applied work, methods regarding choice of competing models have been based largely on maximum R^2 and sign and significance of estimated coefficients. Recently, however, econometricians have become increasingly involved in methods of evaluation of regression models beyond the common ad hoc procedures. Both Bayesian and classical econometricians have developed statistical techniques for evaluating particular models and for choosing among competing models. We discuss and give examples of a number of these contributions, but first a few general comments about the econometric literature dealing with specification issues are in order. Since the econometric issues we discuss apply to any of the economic models of Section 2, we shall use general notation for linear regression models. It should also be noted that the term "model" in this section refers to a precise specification. This means, for example, that two different functional forms for a single behavioral "model" would be classified here as two competing models.

At the risk of over-simplification, we suggest that most specification problems in economic research can be represented by the following simple structure. Suppose a researcher posits a model of the following form:

(7) $$Y = X\beta + \varepsilon$$

where Y is a $T \times 1$ observed vector of dependent variables, X is a $T \times k$ observed regressor matrix of rank k, β is a $k \times 1$ vector of unobserved coefficients and ε is a $T \times 1$ vector of unobserved random deviates. The researcher is interested in an element(s) of β. However, it is usually the case that an alternative model is a likely explanation of Y:

(8) $$Y = X\beta + Z\lambda + \varepsilon$$

The variables in the matrix Z may be transformations of the variables in X, alternative measures of some variable (e.g., real national income versus gross domestic output), other economic variables, or any of a host of factors relevant to explaining variation in Y. In the fortuitous event that the elements of Z are well-specified and observable, there are few difficulties since the bulk of the testing literature deals precisely with such a framework.

However, numerous practical problems can arise in considering the alternative structure: variables may be unobservable, economic theory is typically very vague regarding possibilities for the alternative structure, inclusion of additional variables might exhaust available degrees of freedom, etc. Since interest centers on some element(s) of X and its associated coefficient(s), Z comprises a set of "nuisance" variables which should only be included to the extent that exclusion undermines the quality of estimators of β.[10] A typical response to this problem is to estimate the first model, ignoring the possible relevance

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9 While general expressions for specification bias and inconsistency are well-known, few treatments of the problem give more than simple examples of how poor estimates can be. In the Appendix we present a general regression model, solve for the mean square errors of coefficient estimators both for correct and incorrect models, and then substitute values of the parameters of the model in a demonstration of the impact of specification error.

10 See the Appendix and, in particular, the result that inclusion of a relevant variable can increase the mean square error of coefficient estimators of other variables in the regression.

of the second, and if the estimated equation looks reasonable (coefficients have the right signs and are significant, the R^2 is high, etc.) the results are presented as if they are in some sense a true representation of the effects of X on Y. Another researcher might then criticize the first work because of the possible deleterious effect of omitting Z, alter the regression model by including some of the elements of Z (possibly excluding some of the elements of X) and, if the results look reasonable, present the results. All too often the economic implications change and readers are provided little guidance in choosing between studies. More information needs to be provided about the adequacy of models beyond conformance with a priori expectations.

Closely related to this problem of the possible existance of vague or ill-defined alternative models is the problem of choosing among competing, though well specified, alternative models which are "non-nested", meaning that none of the models can be derived from the others by the use of parametric restrictions. An alternative to model (7) might be written as

(8') $Y = W\gamma + \varepsilon$

where W is known and observable but its elements are not all found in the regressor matrix X nor are the elements of X all found within the matrix W. For example, model (7) might be an import demand function given by (4) in which case import price, other prices, and real national income are elements of the matrix X, and model (8') might explain imports in terms of the price vector and trend income.

There are several recent strands of (often closely related) econometric research germaine to evaluating models such as (7) in the light of possible relevance of a vague or ill-defined alternative model such as model (8), and to choosing among competing non-nested models such as (7) and (8'). For ease of exposition, we discuss this research under four headings: goodness-of-fit, non-nested test procedures, specification searches, and specification error tests. The following is a general discussion, and Section 4 reports examples of each applied to international trade equations.

(A) Goodness-of-Fit Procedures. An early procedure for choosing among competing, though well-specified, econometric models was to select the model with the highest R^2, but this method naturally leads to models with large number of regressors. An alternative is the adjusted R^2 proposed by Theil (1961) and it has become a common model selection procedure. Critics note that maximizing adjusted R^2, as well as R^2, is implicitly justified by some loss function, but the loss function is not explicitly specified. Alternatives based on explicit loss functions are given by Mallows (1964), Akaike (1970, 1973) and Amemiya (1980). Their alternatives to the adjusted R^2 specify a loss function and then derive an estimable measure of that loss which is to be calculated for each of several possible alternative structures. The model which minimizes the specified loss is then chosen.

(B) Non-Nested Test Procedures. Implicit in any use of goodness-of-fit procedures in the assumption that one of the models is the true model since some model is always selected. Non-nested test procedures are an alternative approach which have as a possible outcome the rejection of all models under consideration. This alternative to minimization of loss functions for choosing among non-nested alternatives is based on classical model testing procedures and follows from early work in the statistics literature by Cox (1961, 1962). The idea is to consider each of the models in turn as the null model and one compares the actual performance of the alternative model(s) with the performance that could be expected if the null model were true. For example consider models (7) and (8') as the competing models, and begin by considering model (7) as the null model. Model (8') is estimated first ignoring model (7) and then by assuming model (7) is the true model. The results are compared and if not statistically different we are unable to reject model (7) as the true structure, otherwise we reject model (7). We then repeat the exercise assuming model (8') is the true model and either accept or reject that model based on our estimates of model (7). This approach can lead to an acceptance of both models (implying that the data are unable to distinguish between the models), a rejection of both models (implying that a third, and as yet unspecified model, is the true model), or an acceptance of one of the models and rejection of the other. The ideas underlying the Cox procedures were first applied to regression models by Pesaran (1974) and Pesaran and Deaton (1978); excellent surveys are provided by MacKinnon (1983) and McAleer (1984). An example in international trade is Thursby and Thursby (1987).

(C) Specification searches. How sensitive are results to specification of the model? Much of the formal analysis of specification searches is done within a Bayesian framework and elegant treatments of the ideas can be found in Chamberlain and Leamer (1976), Leamer (1978) and Leamer and Leonard (1983). Cooley (1982) is an early empirical example of specification searches. The argument is made that all researchers have prior notions about parameters of an economic model and, regardless of whether a "classical" or "Bayesian" approach is taken, those prior notions affect the model actually estimated. Unlike formal Bayesian analysts, the proponents of specification searches doubt the efficacy of specifying fully a prior density to represent those prior notions. Rather, they advocate presentation of estimates derived according to different, though reasonable, priors.

Consider a simple example. A researcher posits a model

$$Y_t = \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + u_t \quad .$$

The focus of interest is the coefficient of X_{1t}, a variable known to be an important determinant of Y_t. On the other hand, the researcher considers X_{2t} and X_{3t} to be doubtful variables in the sense that prior densities for β_2 and β_3 would give high probability to values at or close to zero. X_{2t} and X_{3t} are, for the purposes of the research at hand, a pair of "nuisance" variables in that they would be included in the regression only if inclusion improves the estimate of β_1. How does one proceed with the specification search? The simplest, though not the only, approach is to estimate β_1 subject to the constraints $\beta_2=0$, $\beta_3=0$ and $\beta_2=\beta_3=0$ as well as unconstrained, and to present upper and lower bounds for the four estimates of β_1.

(D) Specification Error Tests. An alternative to specification searches is evaluation of a single model using a battery of formal tests of specification as well as possible ad hoc measures of fit. With specification error tests one is often concerned with testing a null model against an alternative that is only vaguely defined. A variety of procedures have been proposed for evaluation of models using specification error tests; recent discussions of methodology and alternative procedures can be found in Pagan (1984), Pagan and Hall (1983), Godfrey (1984), Breusch and Godfrey (1986), Davidson and MacKinnon (1985), and Thursby (1985).

Let the model to be evaluated be given by model (7) above and we can state the null and alternative hypotheses as $E(\varepsilon|X)=0$ and $E(\varepsilon|X)=\phi\neq 0$, respectively, where ϕ is an unobserved $T \times 1$ vector whose nature is unknown to the researcher and ϕ is not orthogonal to X. Thus, under the null hypothesis, estimation of β in model (1) using, say, ordinary least squares gives unbiased estimates of β, whereas under the alternative hypothesis such estimates are biased. Tests of such hypotheses are "nonconstructive" in the sense of Goldfeld and Quandt (1972) or "general" in the sense of Ramsey (1974). A prominent example of such tests is the RESET procedure first proposed by Ramsey (1969) and later modified and extended by Ramsey and Schmidt (1976) and Thursby and Schmidt (1977). The RESET procedure is a standard F test of the significance of the δ estimates in the augmented regression

(9) $$Y = X\beta + V\delta + u$$

where V is a T × G matrix of rank G of test variables such as powers of the X variables. If $\hat{\delta}$ is the ordinary least squares estimator of δ in (9), then the power of the test follows from the fact that

$$E(\hat{\delta}) = (V'MV)^{-1}V'M\phi$$

where $M = I-X(X'X)^{-1}X'$. $E(\hat{\delta})$ is nonzero under general conditions if $\phi\neq0$; hence it is not necessary that the researcher have a prior notion that V and ϕ are related (see Thursby and Schmidt (1977)).

The Hausman test procedure (Hausman (1978)) is an alternative to RESET which is of use when the researcher is able (or willing) to specify the nature of ϕ so that consistent estimators are known under both the null and alternative hypotheses. The Hausman test compares the estimator which is consistent and efficient under the null with an estimator which is always consistent (though inefficient). In general the test can be formulated in the added regressor framework of the RESET procedure (see, for example, Ruud (1984) and Davidson, Godfrey and MacKinnon (1985)).

These various strands of econometric research and methodology are often closely related and can often be fruitfully combined in a single study. For example, specification error tests might be used to eliminate a number of competing models with the remaining (accepted) models subjected to a specification search. We noted above that non-nested tests can be used to reject any or all models under consideration, and in that sense they are specification error tests.

4. Empirical Applications

A. Elasticities and Alternative Specifications of Imports

In Thursby and Thursby (1984) we examined whether the simple, equation specifications of aggregate import demand frequently used in empirical studies were reliable in the sense that they would pass a variety of formal and informal specification tests. We examined a total of 324 estimating equations for each of five countries (Canada, Germany, Japan, United Kingdom and United States). We considered the nine basic models listed in Table 1, each of which is a variant of equation (4). With the exception of model (i), all models introduce dynamic behavior by including lagged values of either the dependent variable or independent variables. Again with the exception of model (i), all models are estimated both in their basic form and including a dummy variable to test for a shift in the demand function or nonconstancy of the income coefficient. The latter test follows from results of Stern, et. al. (1979) which suggest a structural change in United States import demand in 1972 related to income and nonprice factors. To allow for the possibility that the breakdown in the Bretton Woods system after late 1971 or the post-OPEC increase in oil prices could have shifted any country's import demand, we estimated models which allow a shift in 1972.1 (denoted by letter "a" after model number) and in 1974.1 (denoted by letter "b" after model number). For models iic and iid the shifts are permitted in the coefficient of income; whereas for all other models the shifts occur in the intercept term.

All models are estimated in linear and log-linear forms since previous studies had assumed one of these forms. In addition, we estimated each equation using two measures of the dependent variable: the inport quantity index and the real value of imports relative to the price index of imports. Finally, we estimated each equation using three measures of the price of other goods: the implicit price deflator, the wholesale price index, and the consumer price index.

The data are for aggregate quarterly imports for Canada (1957.1 - 1977.4), Germany (1960.1 - 1978.2), Japan (1957.4 - 1977.4), United Kingdom (1957.1 - 1977.3), and United States (1955.1 - 1978.1).[11]

Our model evaluation procedures begin with the RESET procedure using powers of the included regressors as test variables. If the RESET statistic is significant, the model is discarded as being misspecified. If the RESET statistic is insignificant, we apply choice procedures for nested models.[12] If some model is nested within a broader model, we test the coefficients of the variables in the broader model which are not included in the nested model. If significant, we then accept the broader model; otherwise, we accept the nested model. For example, each of the basic models is nested in the same model including a dummy variable. Hence if the coefficient of the dummy variable in any of the lettered models is significant (insignificant), the relevant basic model is rejected (accepted). Next we eliminate models with insignificant income coefficients and/or significant positive price coefficients. Finally we eliminate equations with an adjusted R^2 less than .7.

Table 2 summarizes the results. Columns 2-4 list the percentage of specifications rejected by RESET, nesting, and all other rules (insignificant income coefficient, positive significant price coefficient, or adjusted $R^2<.7$). The last column gives the percentage accepted after all rules are applied. Several general tendencies are evident. Model (i), the only model which does not incorporate dynamic behavior through lagged adjustment, is rejected for every country either by RESET or nesting (88% of these being rejected by RESET). The other striking result is that, by our criteria, including lagged values of the dependent variable appears to be more appropriate than lagged values of price and income.

While the above exercise yields a more manageable number of models than were originally specified, a question remains as to whether the elasticity estimates for the accepted models are different from those for rejected models. Table 3 presents the mean elasticities for four groups of models: (1) accepted, (2) rejected by RESET, (3) rejected by nesting, and (4) those rejected by either the income, price, or adjusted R^2 rules. We tested the hypothesis that the mean elasticity for the accepted models was equal to each of the other means using an anlaysis of variance framework. Whenever a mean elasticity is significantly different from that for accepted models, its level of significance is given in parentheses following the elasticity.

For three short-run income elasticities and two long-run income elasticities, the mean elasticity for accepted models was significantly different from those rejected by RESET. Moreover, for Germany and United States, short-run income elasticities for the accepted models were significantly different from all three other groups.

On the other hand, there are only two cases where the mean price elasticities for accepted models and models rejected by RESET are significantly dif-

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11 Data are from International Monetary Fund International Financial Statistics, and Organization for Economic Cooperation and Development Main Economic Indicators and National Accounts for OECD Countries. All data have been seasonally adjusted.

12 Ordinary least squares is used to calculate the RESET statistic. If the model is accepted we then test for the presence of ARMA processes among the disturbances and, if necessary, correct for the implied process before proceeding to the other model evaluation procedures. See Thursby (1981).

ferent (the Japanese and United Kingdom short-run elasticities). For four countries the mean elasticity for those models rejected by the income, price, or adjusted R^2 rules differs from that of the accepted models.

B. Export Demand Elasticities

To illustrate use of non-nested tests and specification searches we consider a number of single equation specifications of United States wheat exports to Japan. We use annual data for the period 1960 - 1985 and the method of estimation is ordinary least squares (OLS). The models examined are all simple econometric models but are nonetheless models similar to many which have appeared in the empirical literature on export models (see, for example, Gardiner and Dixit (1986), and Gallagher, Lancaster, Bredahl, and Ryan (1981), Konandreas and Schmidtz (1978)). Our intention is not to defend OLS or any particular model, rather we hold constant the data set and provide an example of the use of non-nested test procedures and specification searches.

We start with the regression model

$$(10)\qquad M_t = \beta_0 + \beta_1 Jp/CPI_t + \beta_2 Inc_t + \beta_3 Stks_t + \beta_4 USpr_t + \beta_5 Canpr_t + \beta_6 Strike_t + \varepsilon_t$$

where
M = Japanese per capita imports of US western white #2
Jp = Japanese resale price set by Japanese Food Agency
CPI = Japanese Comsumer Price Index
Inc = per capita real Japanese income
Stks = Japanese per capita beginning stocks + production - exports
USpr = real import price of US western white #2 in yen
Canpr = real import price of Canadian #1 western red spring in yen
Strike = variable to reflect US west coast dock strike activity.[13]

Japanese wheat imports are purchased by the Japanese Food Agency (JFA), a government monopoly, which resells to wholesalers at a fixed price. The resale price is generally set annually and is typically above the import price. While Japanese wholesalers face the resale price set by the JFA and not the United States import price, we nonetheless include the import price because of its possible effects on purchases by the JFA. Due to similar effects we also include the import price of Canadian wheat. Both USpr and Canpr, however, are considered "doubtful" or "unimportant" in the sense that any prior probability densities we might consider for their coefficients would give high probability to values at or close to zero. The variables Stks and Strike are also considered "doubtful" or "unimportant". The specification search, then, begins with consideration of the 16 regressions formed using all possible combinations of Stks, USpr, Canpr and Strike in conjunction with the variables Jp/CPI and Inc.

Several papers (see, for example, Murray and Ginman 1976) have argued that, while homogeneity restrictions may be appropriate for "micro" level import and export demand equations, in equations explaining aggregate flows imposition of such restrictions may lead to a deterioration in the quality of coefficient estimates. Hence we also consider the above set of regressions with Jp and CPI entering separately rather than as a ratio.

Price and income elasticities for the 32 models are given in Table 4. Note that the price elasticities vary over the interval (.002, -.918) and income elasticities vary over the interval (.107, .825).

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13 Data on Japanese production, beginning stocks, imports, exports and resale price are from the Foreign Agricultural Service, USDA. CPI, population and GNP are from International Monetary Fund International Financial Statistics. Import prices are from International Wheat Commission World Wheat Statistics. Strike activity is from Gallagher, Lancaster, Bredahl, and Ryan (1981), updated by the International Longshoreman's and Warehousemen's Union.

Since the models with Jp and CPI entering separately are each a non-nested alternative to a model using the price ratio, the 16 pairs of alternative models can be compared using non-nested test procedures. The particular test procedure we apply is the JA test described as follows (see, for example, McAleer (1984)). Consider the two competing models

$$y = Z_1\theta_1 + u_1$$

and

$$y = Z_2\theta_2 + u_2$$

used to explain the dependent variable y. The regressor matrix Z_1 is not nested in Z_2 nor is Z_2 nested in Z_1. (With respect to our wheat equation, Z_1 might be the regressor matrix consisting of the price ratio Jp/CPI and the variable Stks and Z_2 would be the regressor matrix with varibles Jp, CPI and Stks.) Consider also the augmented regressions

$$y = Z_1\theta_1 + \psi_1 B_2 B_1 y + u_1$$

and

$$y = Z_2\theta_2 + \psi_2 B_1 B_2 y + u_2$$

where

$$B_i = Z_i(Z_i'Z_i)^{-1}Z_i \quad .$$

The JA test consists of t-tests of the two null hypotheses $\psi_1=0$ and $\psi_2=0$. If $\psi_i=0$ is rejected, then we reject the model $y = Z_i\theta_i + u_i$. It is possible to accept both models or to reject both models as well as to accept one and reject the other. A rejection of both models implies that both models are incorrectly specified as a third (and unspecified) model is correct. Acceptance of both models simply means that the data are unable to distinguish between the models.

Using a ten percent significance level we are able to reject every model which uses the split-out prices Jp and CPI rather than the price ratio. Of the price ratio models we reject those models which include the variable Stks. The accepted models are indicated in Table 4 by underlining the price and income elasticities. For the set of accepted models the price elasticities vary over the narrow range (-.745, -.918) and the income elasticities vary over the narrow range (.107, .309). Thus the non-nested procedure rejects those models with low price elasticities and high income elasticities (as well as some models with high price and low income elasticities).

5. Concluding Remarks

Price and income elasticities of demand and supply for imports and exports vary by commodity, country, and time period. Estimates often vary dramatically even when comparisons are limited to studies of narrowly defined commodities exported or imported by a single country. In this survey we have focused on recent literature related to estimation and evaluation of trade elasticities. The approaches we discuss involve testing and evaluation procedures applied both intensively and extensively to models appropriate to the study of trade relationships, and reporting results from the entire exercise. Any hope of narrowing the range of estimated elasticities from trade equations must rely on taking such an approach.

In the first part of the paper we emphasized the need to more carefully specify the underlying economic framework so that estimates of trade model parameters can be more clearly understood. We then turned to a discussion of potential specification errors arising when a researcher's prior notions about the precise specification of a model are vague or ill-defined. Much recent attention has been paid to this problem by econometricians and we reviewed several of the major strands of research relevant to this problem. Finally, we considered several empirical examples which illustrate the potential benefits from a more exhaustive approach to model specification.

Appendix: A General Model of Specification Error

In order to gain insight into specification error we consider a simple, though revealing, regression model subject to specification error. The model is a quite general regression model with two included regressors and an arbitrary number of omitted regressors. Our purpose is to see more clearly the relation between parameters of the misspecified models and mean square error (MSE) of estimators of included regressor coefficients.

Consider the model

(A1) $$Y_t = \beta_1 X_{1t} + \beta_2 X_{2t} + Z_t'\alpha + u_t \qquad t=1,\ldots,n$$

where the regressors X_{1t} and X_{2t} are scalars, Z_t is a column vector of regressors and t refers to the observational unit. For expositional ease define $X_{3t} \equiv Z_t'\alpha$. Without loss of generality all variables are assumed to have zero means. β_1, β_2 and α are composed of unknown regression coefficients and the u_t are independent and identically distributed with mean zero and variance σ_{uu}. For analytic ease we assume that Y_t, X_{1t}, X_{2t}, and X_{3t} are multivariate normal. The vectors $X_t = (X_{1t}, X_{2t}, X_{3t})'$ are independent of u_t and distributed identically across t with covariance matrix

$$\Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_{22} & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_{33} \end{bmatrix} .$$

Let us suppose that the researcher is interested in the coefficient β_1 of X_{1t}. We shall compare the mean square error (MSE) of the ordinary least squares estimator of β_1 in the regression of Y_t on X_{1t}, X_{2t}, and X_{3t} ($MSE(\hat{\beta}_1)$) with the MSE of β_1 in the regression in which the researcher erroneously <u>omits</u> X_{3t} ($MSE(\tilde{\beta}_1)$).[14]

Based on results in Aigner (1974) and Kinal and Lahiri (1983), it is easy to show that

$$MSE(\tilde{\beta}_1) = \frac{\sigma_{33}}{\sigma_{11}(1-\rho_{12}^2)^2} \Big\{ (\rho_{13}-\rho_{12}\rho_{23})^2 + [\sigma_{uu}(1-\rho_{12}^2)/\sigma_{33} + 1 + 2\rho_{12}\rho_{13}\rho_{23} - \rho_{12}^2 - \rho_{13}^2 - \rho_{23}^2]/(n-3) \Big\}$$

and $$MSE(\hat{\beta}_1) = \frac{\sigma_{uu}(1-\rho_{23}^2)}{\sigma_{11}(n-4)} (1 + 2\rho_{12}\rho_{13}\rho_{23} - \rho_{12}^2 - \rho_{13}^2 - \rho_{23}^2)^{-1}$$

where ρ_{ij} is the simple correlation of X_{it} and X_{jt}. Note that for positive definiteness of Σ it is necessary that

(A2) $$1 + 2\rho_{12}\rho_{13}\rho_{23} - \rho_{12}^2 - \rho_{13}^2 - \rho_{23}^2 > 0 .$$

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14 This representation of specification error is very general and can refer to omitted variables (in an obvious way), incorrect functional form (the omitted term becomes the sum of second and higher order terms in a Taylor series expansion of the true function), endogenous regressors (the omitted term then represents that part of the true disturbance correlated with the regressors), etc.

(A2) $$1 + 2\rho_{12}\rho_{13}\rho_{23} - \rho_{12}^2 - \rho_{13}^2 - \rho_{23}^2 > 0 \quad .$$

As an indication of the potential problems with the omission of X_{3t} we calculate values of $MSE(\hat{\beta}_1)$ and $MSE(\tilde{\beta}_1)$ for the parameter values

ρ_{12}, ρ_{13} and ρ_{23}= .0, .5, .75, .9;

$\sigma_{uu} = \sigma_{11} = 1$;

$\sigma_{33} = 1$ and .2; and

$n = 25$ and 100

and results for $MSE(\hat{\beta}_1)$ and $MSE(\hat{\beta}_1)/MSE(\tilde{\beta}_1)$ are found in Tables A1 and A2. Two points of particular interest to emerge are (1) MSE's of the two estimators vary a great deal as parameters and estimators vary, and (2) the exclusion of X_{3t} can actually lead to an inprovement in the estimation of β_1 (see, especially, results for $\sigma_{33} = .2$, $n = 25$ and $\rho_{23} = .9$).[15]

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15 See also Wallace (1964) and Leamer (1983).

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Table A1. Mean Square Errors - Omitted Variables and Errors in Variables Models; $\sigma_3^2=1$

	MSE(OV)				MSE(OV)/MSE(TR)			
	ρ_{12}							
ρ_{13}	.0	.5	.75	.9	.0	.5	.75	.9
A. n = 25								
				ρ_{23} = .0				
.0	.09	.12	.21	.48	1.91	1.91	1.91	1.91
.5	.33	.55	1.45	*	5.19	5.73	5.73	*
.75	.63	1.08	*	*	5.77	4.24	*	*
.9	.86	*	*	*	3.45	*	*	*
				ρ_{23} = .5				
.0	.08	.21	.88	*	1.67	2.97	4.64	*
.5	.32	.21	.26	.48	4.45	2.97	2.27	1.90
.75	.62	.53	.88	2.80	3.24	4.64	4.64	4.11
.9	*	.82	1.56	*	*	3.23	2.29	*
				ρ_{23} = .75				
.0	.07	.33	*	*	1.37	2.93	*	*
.5	.3	.11	.17	1.15	2.74	1.70	1.52	2.91
.75	*	.33	.32	.49	*	2.93	2.44	1.83
.9	*	.55	.72	1.68	*	1.40	2.67	2.62
				ρ_{23} = .9				
.0	.05	*	*	*	1.14	*	*	*
.5	*	.08	.28	*	*	1.18	1.60	*
.75	*	*	.22	.15	*	*	1.30	1.30
.9	*	*	.38	.50	*	*	1.35	1.54
B. n = 100								
				ρ_{23} = .0				
.0	.02	.03	.05	.11	1.98	1.98	1.98	1.98
.5	.27	.47	1.34	*	19.30	22.43	24.12	*
.75	.58	1.02	*	*	24.25	18.31	*	*
.9	.82	*	*	*	15.00	*	*	*
				ρ_{23} = .5				
.0	.02	.13	.77	*	1.73	8.58	18.44	*
.5	.27	.13	.12	.16	16.99	8.58	4.88	2.93
.75	.57	.46	.77	2.56	13.79	18.56	18.44	17.22
.9	*	.77	1.47	*	*	13.75	9.85	*
				ρ_{23} = .75				
.0	.01	.27	*	*	1.42	10.99	*	*
.5	.26	.05	.05	.92	10.79	3.24	2.22	10.57
.75	*	.27	.22	.23	*	10.99	7.39	3.95
.9	*	.5	.62	1.47	*	5.81	10.59	10.45
				ρ_{23} = .9				
.0	.01	*	*	*	1.18	*	*	*
.5	*	.02	.19	*	*	1.47	4.94	*
.75	*	.17	.06	.16	*	4.63	2.24	2.68
.9	*	*	.29	.29	*	*	4.76	4.06

Table A2. Mean Square Errors - Omitted Variables and Errors in Variables Models; $\sigma_3^2=.2$

	MSE(OV)				MSE(OV)/MSE(TR)			
	ρ_{12}							
ρ_{13}	.0	.5	.75	.9	.0	.5	.75	.9
A. n = 25								
					ρ_{23} = .0			
0	.05	.07	.12	.29	1.15	1.15	1.15	1.15
.5	.1	.16	.37	*	1.61	1.65	1.47	*
.75	.16	.26	*	*	1.49	1.04	*	*
.9	.21	*	*	*	.83	*	*	*
					ρ_{23} = .5			
0	.05	.09	.26	*	1.10	1.27	1.36	*
.5	.10	.09	.14	.29	1.40	1.27	1.18	1.13
.75	.16	.15	.26	.75	.84	1.35	1.36	1.10
.9	*	.21	.39	*	*	.84	.58	*
					ρ_{23} = .75			
0	.05	.11	*	*	1.04	1.02	*	*
.5	.1	.07	.12	.42	.87	1.07	1.05	1.06
.75	*	.11	.15	.29	*	1.02	1.11	1.08
.9	*	.16	.23	.53	*	.40	.84	.82
					ρ_{23} = .9			
0	.05	*	*	*	.99	*	*	*
.5	*	.06	.14	*	*	.99	.8	*
.75	*	.09	.11	.27	*	.54	.97	.96
.9	*	*	.16	.29	*	*	.57	.9
B. n = 100								
					ρ_{23} = .0			
0	.01	.02	.03	.07	1.19	1.19	1.19	1.19
.5	.06	.10	.29	*	4.45	5.01	5.16	*
.75	.12	.21	*	*	5.20	3.86	*	*
.9	.17	*	*	*	3.15	*	*	*
					ρ_{23} = .5			
0	.01	.04	.17	*	1.14	2.42	4.14	*
.5	.06	.04	.04	.08	3.93	2.42	1.73	1.36
.75	.12	.1	.17	.56	2.96	4.15	4.14	3.74
.9	*	.16	.31	*	*	2.95	2.1	*
					ρ_{23} = .75			
0	.01	.06	*	*	1.08	2.65	*	*
.5	.06	.02	.03	.23	2.50	1.40	1.22	2.61
.75	*	.06	.06	.09	*	2.65	2.13	1.53
.9	*	.11	.14	.34	*	1.29	2.44	2.40
					ρ_{23} = .9			
0	.01	*	*	*	1.03	*	*	*
.5	*	.02	.06	*	*	1.07	1.49	*
.75	*	.05	.03	.08	*	1.22	1.19	1.25
.9	*	*	.08	.10	*	*	1.26	1.43

1. Alternative Models of Import Demand

i.	$Y_t = f(P_t, I_t)$
ii.	$Y_t = f(P_t, I_t, Y_{t-1})$
iia.	$Y_t = f(P_t, I_t, Y_{t-1}, D72)$
iib.	$Y_t = f(P_t, I_t, Y_{t-1}, D74)$
iic.	$Y_t = f(P_t, I_t, Y_{t-1}, D72*I_t)$
iid.	$Y_t = f(P_t, I_t, Y_{t-1}, D74*I_t)$
iii.	$Y_t = f(P_t*P_{t-1}, I_t*I_{t-1}, Y_{t-1})$
iiia.	$Y_t = f(P_t*P_{t-1}, I_t*I_{t-1}, Y_{t-1}, D72)$
iiib.	$Y_t = f(P_t*P_{t-1}, I_t*I_{t-1}, Y_{t-1}, D74)$
iv.	$Y_t = f(P_{1t}, P_{2t}, I_t, Y_{t-1})$
iva.	$Y_t = f(P_{1t}, P_{2t}, I_t, Y_{t-1}, D72)$
ivb.	$Y_t = f(P_{1t}, P_{2t}, I_t, Y_{t-1}, D74)$
v.	$Y_t = f(P_{1t}, P_{2t}, I_t/IT_t, IT_t, Y_{t-1})$
va.	$Y_t = f(P_{1t}, P_{2t}, I_t/IT_t, IT_t, Y_{t-1}, D72)$
vb.	$Y_t = f(P_{1t}, P_{2t}, I_t/IT_t, IT_t, Y_{t-1}, D74)$
vi.	$Y_t = f(P_t, I_t/IT_t, IT_t, Y_{t-1})$
via.	$Y_t = f(P_t, I_t/IT_t, IT_t, Y_{t-1}, D72)$
vib.	$Y_t = f(P_t, I_t/IT_t, IT_t, Y_{t-1}, D74)$
vii.	$Y_t = f(P_t, P_{t-1}, I_t, I_{t-1})$
viia.	$Y_t = f(P_t, P_{t-1}, I_t, I_{t-1}, D72)$
viib.	$Y_t = f(P_t, P_{t-1}, I_t, I_{t-1}, D74)$
viii.	Y_t = f(Almon lag on P_t and I_t)
viiia.	Y_t = f(Almon lag on P_t and I_t, D72)
viib.	Y_t = f(Almon lag on P_t and I_t, D74)
ix.	Y_t = f(Almon lag on P_{1t}, P_{2t} and I_t)
ixa.	Y_t = f(Almon lag on P_{1t}, P_{2t} and I_t, D72)
ixb.	Y_t = f(Almon lag on P_{1t}, P_{2t} and I_t, D74)

where Y = quantity of imports
I = Real Gross Domestic Product
P = price of imports relative to other goods
D = dummy variable beginning in indicated year
P_1 = price of imports
P_2 = price of other goods
IT = trend income

Source: Table 1 of Thursby and Thursby (1984).

Table 2. Import Demand Model Outcomes

Model	RESET	Nested Test	All Other	Percentage Accepted
	Percentage Rejected by Rule			
		All Countries		
1	88	12	0	0
2	42	28	10	20
3	48	21	7	24
4	71	12	6	12
5	65	16	8	11
6	53	19	9	19
7	80	6	7	8
8	95	1	2	2
9	77	11	4	8
All Models	65	15	7	13
		Canada		
All Models	73	11	3	13
		Germany		
All Models	59	13	2	26
		Japan		
All Models	63	20	2	15
		United Kingdom		
All Models	53	18	24	5
		United States		
All Models	79	13	1	7

Source: Table 2, Thursby and Thursby (1984)

Table 3. Import Demand Mean Elasticites

Model	Income Elasticities Short-run	Income Elasticities Long-run	Price Elasticities Short-run	Price Elasticities Long-run
		Canada		
1. Accepted	1.20	1.35	-.19	-.46
2. RESET	.96 (5)	1.42	-.25	-.50
3. Nested	1.36	1.13	-.02 (5)	-.26 (5)
4. All other	1.66 (5)	1.00 (25)	.29 (5)	.04 (5)
		Germany		
1. Accepted	.98	1.59	-.22	-.30
2. RESET	1.08 (15)	1.24 (5)	-.24	-.29
3. Nested	1.12 (15)	1.48	-.24	-.23 (25)
4. All other	1.65 (5)	1.37	-.42 (5)	-.37
		Japan		
1. Accepted	.76	1.17	-.17	-.33
2. RESET	.84	1.15	-.10 (10)	-.40
3. Nested	.84	1.25	-.13	-.23
4. All other	1.27 (5)	1.04	-.08	-.15
		United Kingdom		
1. Accepted	.78	1.12	.10	.14
2. RESET	.75	.97	.17 (25)	.18
3. Nested	.72	1.04	.19 (20)	.24 (15)
4. All other	.62	.90 (25)	.03 (25)	.05 (20)
		United States		
1. Accepted	1.50	1.72	-.04	-.20
2. RESET	.77 (5)	1.39 (5)	-.00	-.14
3. Nested	1.84 (5)	1.83	-.03	-.16
4. All other	2.36 (5)	1.81	.24 (5)	.19 (5)

Source: Table 3 of Thursby and Thursby (1984).

Table 4. Wheat Export Elasticities

Independent Variables									
Jp/CPI	Jp	CPI	Inc	Stks	USpr	Canpr	Strike	Price Elast.	Income Elast.
X			X					-.745*	.221
X			X	X				-.270	.388
X			X		X			-.780*	.302
X			X			X		-.791*	.286
X			X				X	-.887*	.107
X			X	X	X			-.302	.396
X			X	X		X		-.307	.396
X			X	X			X	-.523*	.244
X			X		X	X		-.763*	.309
X			X		X		X	-.905*	.167
X			X			X	X	-.918*	.159
X			X	X	X	X		-.299	.393
X			X	X	X		X	-.544	.249
X			X	X		X	X	-.557*	.252
X			X		X	X	X	-.911*	.165
X			X	X	X	X	X	-.541	.242
	X	X	X					-.258	.825*
	X	X	X	X				.002	.259
	X	X	X		X			-.447	.794*
	X	X	X			X		-.418	.817*
	X	X	X				X	-.620	.635*
	X	X	X	X	X			-.003	.259
	X	X	X	X		X		-.007	.257
	X	X	X	X			X	-.339	.165
	X	X	X		X	X		-.456	.773*
	X	X	X		X		X	-.759	.615*
	X	X	X			X	X	-.749	.631*
	X	X	X	X	X	X		-.012	.241
	X	X	X	X	X		X	-.327	.164
	X	X	X	X		X	X	-.331	.164
	X	X	X		X	X	X	-.757	.622*
	X	X	X	X	X	X	X	-.325	.169

* Coefficient associated with elasticity significant at the 10% level.

	DATE DUE		