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Some Lessons from the Modelling of the Spanish Rice Market

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Abstract

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Spanish accession to the European Comminity (EC) will lead to many changes in Spain's agricultural sector. Predicting the nature of these changes is difficult because the new policy regime differs significantly from historic Spanish policies. In this paper, conventional econometric models of the Spanish rice sector are constrated with a model designed specifically to reflect the pervasive impact of Spanish rice policies. This policy model predicts the historical evolution of production, consumption and trade more accurately than the conventional models. However, the policy model cannot be used to predict the impact of the radical policy changes in Spain resulting from the introduction of the EC rice regime because the historical relationships no longer hold. It is argued that alternative approaches relying more on institutional analysis and expert opinion need to be developed to understand the future of the Spanish rice sector.

Introduction

The purpose of this paper is to present a plausible model of the Spanish rice market. The research reported here is part of a larger project, the objective of which is to evaluate the demand for imported rice in the European Community (EC). Of the twelve countries belonging to the EC, only Spain and Italy are net exporters of rice, and only three others (France, Greece and Portugal) produce any rice at all. For the EC as a whole, the degree of self-supply is less than 70% (Agra Europe, 1985). The EC thus represents a significant market for rice exporting nations. Spain and Portugal were admitted to the EC in

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January 1986 and their agricultural support prices will gradually be aligned with those in the EC. With accession, Spanish rice prices will increase by about 32% as the higher EC support prices are phased in (Agra Europe, 1986). The motivation for this study is to evaluate the impact of Spanish accession on the Spanish and EC rice markets.

A common approach to this type of problem is to introduce exogenous policy variables into a structural econometric model which is then used to predict outcomes under alternative levels of the policy variables (Ferris et al., 1971; Peterson et al., 1983). This approach has been criticized for several reasons. It has been argued that the underlying structural parameters may not be fixed and invariant to the policy regime in place, so that changing the policies may also change the structure of the econometric model (Sheffrin, 1983). Others have objected to treating policy as exogenous noting that policy decisions are influenced by current economic events as well as political processes (Rausser et al., 1982; Petit, 1985). In this paper, this conventional approach is contrasted with an alternative model that is specifically designed to reflect the influence of policy on Spanish rice production, consumption and trade.

In the first part of the paper, standard econometric models are presented and estimated. The second part includes a review of Spanish rice policy and a comparison of a policy model with the models decribed in the preceding section. The implications of the results are discussed in the final portion of the paper.

Conventional Approaches to Modelling an Agricultural Market

Many textbook discussions of agricultural supply and demand present what may bee thought of as a standard model specification (see e.g. Tomek and Robinson, 1981, pp. 314–319). These models typically include equations representing acreage, domestic consumption, stocks and net exports (imports). Occasionally, a yield equation is also included. For this study, no statistical relationships could be found for rice yields. This is not surprising since yields depend on highly site-specific weather conditions for which data were not available. Because Spanish rice yields are fairly high and have not varied greatly over the past 25 years little is lost by treating yields as exogenous. The typical systems of equations are closed with an identity equating total availability (beginning stocks, imports, and production —i.e. acreage times yield) to total disappearance (domestic consumption, exports and ending stocks).

Although model specifications vary greatly, certain variables are frequently included in the equations. For the acreage equation, a common specification is to include the lagged real price and the lagged dependent variable, a measure of production costs and, the real price of a competing crop. In Spain, rice is grown only in areas of high salinity and there are no competing crops (Camilleri, 1984, p. 377). Domestic demand is usually modelled as dependent on real income, real own price and the real prices of substitutes or complements. In the following examples, the real price of potatoes is included as the main consumer substitute for rice. Net exports are generally assumed to depend on world prices, income levels in importing countries, and the domestic price. The Thailand rice export price expressed in real pesetas is used to represent the world price, and real per capita income in Morocco is included as a proxy for North African income, since North Africa represents one of the most important markets for Spanish rice. Stock levels are frequently modelled as a function of domestic prices and a measure of the cost of holding stocks such as the interest rate. In the following example, the Spanish discount rate is used as a proxy for the relevant interest rate. Many variations on this basic specification could, of course, be imagined.

Before presenting typical econometric models of the Spanish rice market, some comments on the data used are in order. Two sources of data on rice production, consumption, trade and stocks were located. The United States Department of Agriculture has published rice data for many countries covering the period 1960 to 1982 (USDA, 1983). The Spanish Ministry of Agriculture also provides data on rice (Secretaría General Técnica, 1982; OECD, 1984). These two sets of data include acreage, yields, production, beginning stocks (or changes in stocks), domestic consumption and net exports for the period 1960 to 1982. The data for acreage, yield and production are quite similar, but values for the other variables differ radically. For this study, the USDA data were chosen since the stock variable appeared more reasonable. The stock changes reported in the Spanish data imply stock levels in the 1960's that would have been larger than total production. As is noted later, even the USDA stock data are suspect, but in the absence of other critiria for choosing between the data sets, this anomaly led to the choice of the USDA data set. Prices and other explanatory variables are taken from Spanish sources as reported in IMF (1983), OECD (1981, 1984) or Spanish publications. All price, income and expenditure data are deflated by Spain's consumer price index.

A conventional model of the Spanish rice rector was estimated and the results are shown in equations (1) to (4). This and the other models described were estimated with three-stage least squares. In addition to the dependent variables in the equations, the real price (DRPR) is also endogenous. The variables are defined in Table 1. The figures in parenthese are T ratios.

— Rice acreage:

$$\text{RAC} = \underset{(3.140)}{32.226} + \underset{(0.152)}{0.131}\ \text{LAGDRP} - \underset{(-1.576)}{0.0835}\ \text{DPPAG} + \underset{(4.214)}{0.586}\ \text{LAGRAC} \quad (1)$$

— Per-capita consumption:

$$\text{PCCU} = \underset{(4.310)}{6.836} - \underset{(-0.244)}{0.0576}\ \text{DRPR} - \underset{(-1.242)}{0.253}\ \text{DPOT} + \underset{(0.141)}{0.0017}\ \text{RPCY} \quad (2)$$

— Net exports:

$$\text{UXS} = \underset{(0.111)}{8.677} - \underset{(-0.883)}{0.0019}\ \text{RTHAX} + \underset{(0.003)}{0.051}\ \text{PCMY} + \underset{(1.360)}{11.75}\ \text{DRPR} \qquad (3)$$

— Change in stocks:

$$\text{DELSTK} = \underset{(-4.73)}{-288.48} + \underset{(0.710)}{2.114}\ \text{DISCR} - \underset{(-0.970)}{4.826}\ \text{DRPR} + \underset{(5.68)}{4.96}\ \text{RYLD} \qquad (4)$$

The weighted R^2 for the system corresponding to an approximate F test on all non-intercept parameters is 0.61. The second-stage Durbin–Watson statistic for the per capita consumption equation is 1.02, suggesting the presence of autocorrelation in that equation. Of the twelve explanatory variables in the system, only two are significantly different from zero at the most commonly accepted levels of significance. In these circumstances, little can be said about the appropriateness of the signs on the estimated coefficients.

Overall, these results are not very encouraging. A common response to this kind of problem is to collect more data and re-estimate the system with different combinations of explanatory variables. This approach was pursued with little improvement in the results. However, some insights were gained from this search process. In particular, closer examination of the acreage and stock series raised questions about the appropriate treatment of these variables. From

TABLE 1

Variable definitions

	Symbol	Definition
(A)	*Endogenous variables*	
	RAC	Rice acreage (1000 ha)
	PCCU	Per-capita annual milled rice consumption (kg)
	UXS	Net exports (1000 metric tons of milled rice)
	DELSTK	Beginning minus ending stocks of milled rice (1000 metric tons)
	DRPR	Real price received by producers (pesetas per kg)
	PCDD	Per-capita domestic disappearance (consumption plus stock variations) of milled rice (kg)
(B)	*Exogenous and predetermined variables*	
	DPPAG	Real index of prices paid by producers
	DPOT	Real price of potatoes (pesetas per kg)
	RPCY	Real per-capita GDP (1000 pesetas)
	RTHA	Thai export price expressed (real pesetas per metric ton)
	PCMY	Real per-capita income in Morocco (1000 dirhams)
	DISCR	Spanish discount rate (%)
	RYLD	Rough rice yield (100 kg per ha)
	RSUB	Real government subsidies to agriculture (millions of pesetas)
	LAGRAC	Rice acreage lagged one period
	LAGDRP	Real producer price for rice lagged one period
	POP	Spanish population (millions)

Spanish peseta = US$ 0.0065 (1985)
Morocco dirham = US$ 0.1042 (1985)

1961 to 1976, acreage ranged from 59 000 to 64 000 ha. From 1977 to 1982 the range was from 67 600 to 69 000 ha. No explanation for this shift was found in written discussions of the Spanish rice sector. A number of hypotheses concerning irrigation developmment were tested and rejected, perhaps because aggregate data for Spain had to be used as proxies for location and crop specific series that would have been preferred. Another possible explanation, a shift in policy, will be explored later.

The problem with the stock data is that no change in beginning stocks was reported from 1960 to 1974. This does not seem plausible and, more importantly, leads to some statistical anomalies. For example, the Spanish exchange rate and consumer price index, both of which remained relatively stable until the early 1970's, are highly correlated with the level of beginning stocks. One could invent a reasonable explanation for this relationship but it may be that the correlation is spurious. Assuming that production and net trade were measured with greater accuracy than stocks or consumption, it is reasonable to treat stock variations as part of domestic demand. The system was reestimated using this specification with the results reported in equations (5) to (7):

— Rice acreage:

$$\text{RAC} = \underset{(2.99)}{34.298} - \underset{(-0.379)}{0.364}\ \text{LAGDRP} - \underset{(-1.062)}{0.061}\ \text{DPPAG} + \underset{(3.672)}{0.565}\ \text{LAGRAC} \qquad (5)$$

— Per-capita domestic disappearane (consumption plus stock variations):

$$\text{PCDD} = \underset{(3.670)}{7.582} - \underset{(-0.426)}{0.131}\ \text{DRPR} + \underset{(0.072)}{0.001}\ \text{RPCY} - \underset{(1.230)}{0.336}\ \text{DPOT} \qquad (6)$$

— Net exports:

$$\text{UXS} = \underset{(0.196)}{17.73} - \underset{(-0.716)}{0.002}\ \text{PCMY} + \underset{(-0.100)}{11.102}\ \text{DRPR} \quad (1.100) \qquad (7)$$

The weighted R^2 for this system is 0.52, and only one of the nine explanatory variables is significantly different from zero. Clearly, this does not constitute an improvement on the four-equation system. Deletion of the equation for stock variations eliminates the strong relationship between stock levels and yields, thus weakening the entire system. As with the four-equation system, alternative combinations of explanatory variables were explored with little success. The stylized textbook model outlined at the beginning of this section does not appear to provide a very good description of this market.

An alternative approach: modelling policy

The rather unsatisfactory results presented in the preceding section are not surprising. Herruzo notes that there are only two estimates of the price elasticity of domestic demand for rice (one of which is highly suspect) and no estimates of supply elasticites (1985, pp. 270–271). One possible explanation for the difficulty in establishing statistical relationships for the Spanish rice sector is that the data are unreliable. This is a very real possibility. Another possible explanation is that, historically, government intervention in this market has been so pervasive that the underlying economic relationships are obscured in the recorded data. To explore this possibility it is necessary to examine Spanish policy more closely.

The following description of the rice sector in Spain is drawn primarily from Berenguer (1982) and Camilleri (1984). Rice production in Spain is limited to certain coastal regions (Andalucia Occidental. Levante and Nordeste) where salinity precludes the cultivation of alternative crops. Furthermore, during the period for which data are available, producers were required each year to report to various government agencies the number of hectares they planned to cultivate as well as their harvests. The main state agency dealing with rice and other cereal grains was the Servicio Nacional de Productos Agrarios (SENPA). Prior to Spanish accession to the EC, SENPA purchased virtually all of the rough rice harvested at a guaranteed price set by the government. The state also had complete control of exports which, according to Camilleri, were treated as a "residual" (p. 391). In other words, exports were regulated to equilibrate supply and demand on the internal market. The state may also have controlled stocks and, presumably, set the price millers paid for the rough rice harvest. If retail prices rose to a certain level, export were suspended. Overall, the Spanish government exercised almost complete control of the rice market during the period for which data are available.

A model describing this market should include the prominent role of the state. One way to do this would be to treat real prices as exogenous variables determined by policy. The equations could then be estimated with ordinary least squares (OLS). A large number of OLS equations were estimated using various combinations of explanatory variables. The results were not encouraging and are not reported here. Another approach to including government policy is to introduce an equation relating price to variables that government agents might consider in determining the level at which to set the price. This approach led to somewhat better results. It was assumed that the price was set after farmers had declared their acreage to the state. The number of hectares planted depended on individual producer decisions to some extent, but was probably also influenced by government interventions. Similarly, domestic disappearance (consumption plus stock variations) involved a mixture of individual and bureaucratic responses. Finally, an appropriate model of this industry should explicitly recognize the residual nature of exports. With these considerations in mind, the following model was developed:

— Rice acreage:

$$\text{RAC} = f_a(\text{LAGRAC, RSUB, DPPAG}) \quad (8)$$

— Real producer price:
$DRPR = f_p(RAC, RTHAX, DPPAG)$ (9)

— Per-capita disappearance:
$PCDD + f_d(UXS, DRPR, RYLD, RPCY)$ (10)

— Identity to determine exports:
$UXS \equiv (RAC)(RYLD) - (PCDD)(POP)$ (11)

As noted earlier, there was a shift in harvested rice acreage from an average of 61 600 ha for the period 1961–76 to an average of 68 350 ha for 1977–82. While no explanation for this shift was found, it is possible that the shift reflects a change in government policy, since the requirement to declare acreage represents at least an implicit control on acreage. Initially a dummy variable was used to capture this shift but this obscured the effects of other explanatory variables. Consequently, the dummy variable was dropped. Including lagged acreage as an explanatory variable reflects the fact that the area suitable for rice cultivation is relatively fixed and, aside from the shift in 1977, total harvested acreage is determined by marginal adjustments in this base. The other variables included are the real cost of inputs and the value of real government subsidies to agriculture. The cost variable is included to capture the effect of decisions by farmers, while the subsidy variable is used as a proxy for government support for agriculture, including the rice sector. The expected signs are positive for the coefficients of lagged acreage and government subsidies, and negative for costs.

Real producer prices are modelled as a function of acreage, producer costs and the real world price. It is assumed that the state agencies are subject to political pressure from farm groups and must take farm income into account in setting prices. If producer costs are rising there should be pressure to raise prices. On the other hand, increases in declared acreage may result in lower real prices because the income constraint would be relaxed and the state may wish to discourage further increases in output. The coefficients are thus expected to be negative for acreage and positive for real costs. The world price is also included to reflect the hypothesis that world market conditions are taken into consideration in setting domestic prices. It is expected that the coefficient for this variable would be positive.

On the basis of the written descriptions of Spanish export policy, it is assumed that per capita domestic disappearance and exports are inversely related. Consumer demand is expected to depend on price and income. The price coefficient should be negative while the coefficient for real income may be negative or positive depending on whether rice is considered to be an inferior good. One of the few variables outside the control of the state is yield. This variable is included in the per capita disappearance equation to reflect the impact of unsually good or bad harvests on stocks. It is expected that yields are positively related to domestic disappearance. The results of estimating this system are shown in equations (12) to (14):

— Rice acreage:

$$\text{RAC} = 32.98 + 0.517\ \text{LAGRAC} + 0.0006\ \text{RSUB} - 0.059\ \text{DPPAG} \quad (12)$$
$$(3.4) \quad (3.87) \quad (1.8) \quad (-1.72)$$

— Real producer price:

$$\text{DRPR} = 5.51 - 0.067\ \text{RAC} + 0.0001\ \text{RTHAX} + 0.037\ \text{DPPAG} \quad (13)$$
$$(1.51) \quad (-1.38) \quad (3.178) \quad (3.98)$$

— Per-capita domestic disappearance:

$$\text{PCDD} = 6.5 - 0.049\ \text{UXS} - 0.211\ \text{DRPR} + 0.071\ \text{RYLD} - 0.021\ \text{RPCY} \quad (14)$$
$$(2.18) \quad (-5.8) \quad (-1.41) \quad (2.00) \quad (-1.63)$$

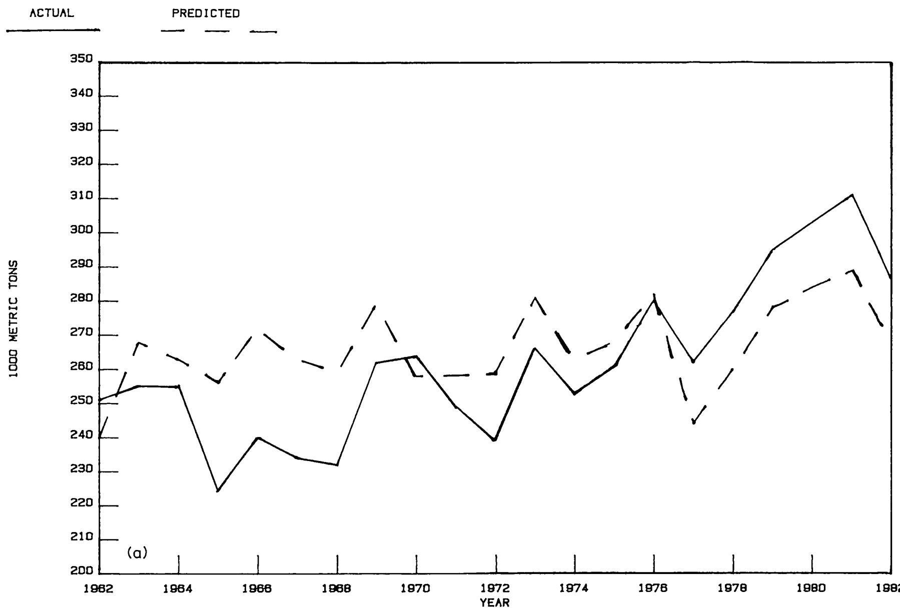
The weighted R^2 for this system is 0.71. The coefficients for seven of the ten explanatory variables are significantly different from zero at the 90% confidence level and all have the expected signs. On the basis of the structural coefficients in this model and the three-equation model presented in the preceding section, two sets of reduced form equations were derived and used to simulate the historical period. The root mean square errors and percentage root mean square errors for the two models are shown in Table 2. While the measures of fit for the two acreage equations are similar, it is clear that the policy model provides better predictions of domestic disappearance.

To further compare the two models, predicted acreage and per-capita disappearance were multiplied by yield and population respectively to determine predicted production and disappearance. Exports are predicted directly in the standard model, but are computed as the difference between production and consumption in the policy model. Actual and predicted values of production, consumption and net exports from two models are shown in Fig. 1 to 3. Because the two acreage equations are similar, the plots of actual and predicted production do not differ greatly. However, the plots for domestic disappearance and net exports clearly indicate the superiority of the policy model in describing the historical evolution of these variables.

TABLE 2

Root mean square error and percentage root mean square error for equations in the policy and standard models

Variable	Standard model		Policy model	
	RMS Error	RMS% Error	RMS Error	RMS% Error
RAC	2.401	3.89	2.343	3.75
PCDD	0.856	15.91	0.395	6.99
UXS	22.260	129.37	-	-
DRPR	-	-	0.300	5.29



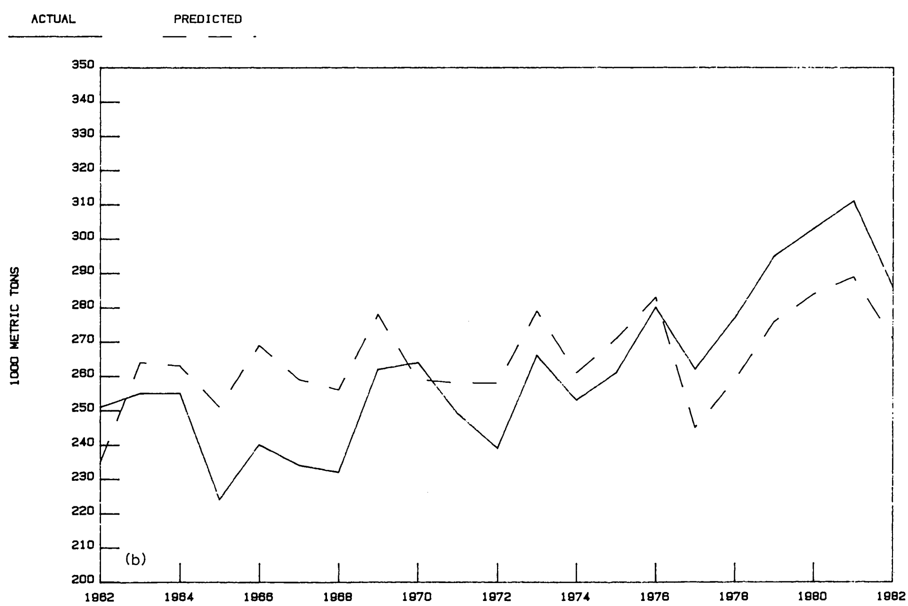


Fig. 1. Rice production in Spain: (a) rice production standard model; (b) rice production policy model.

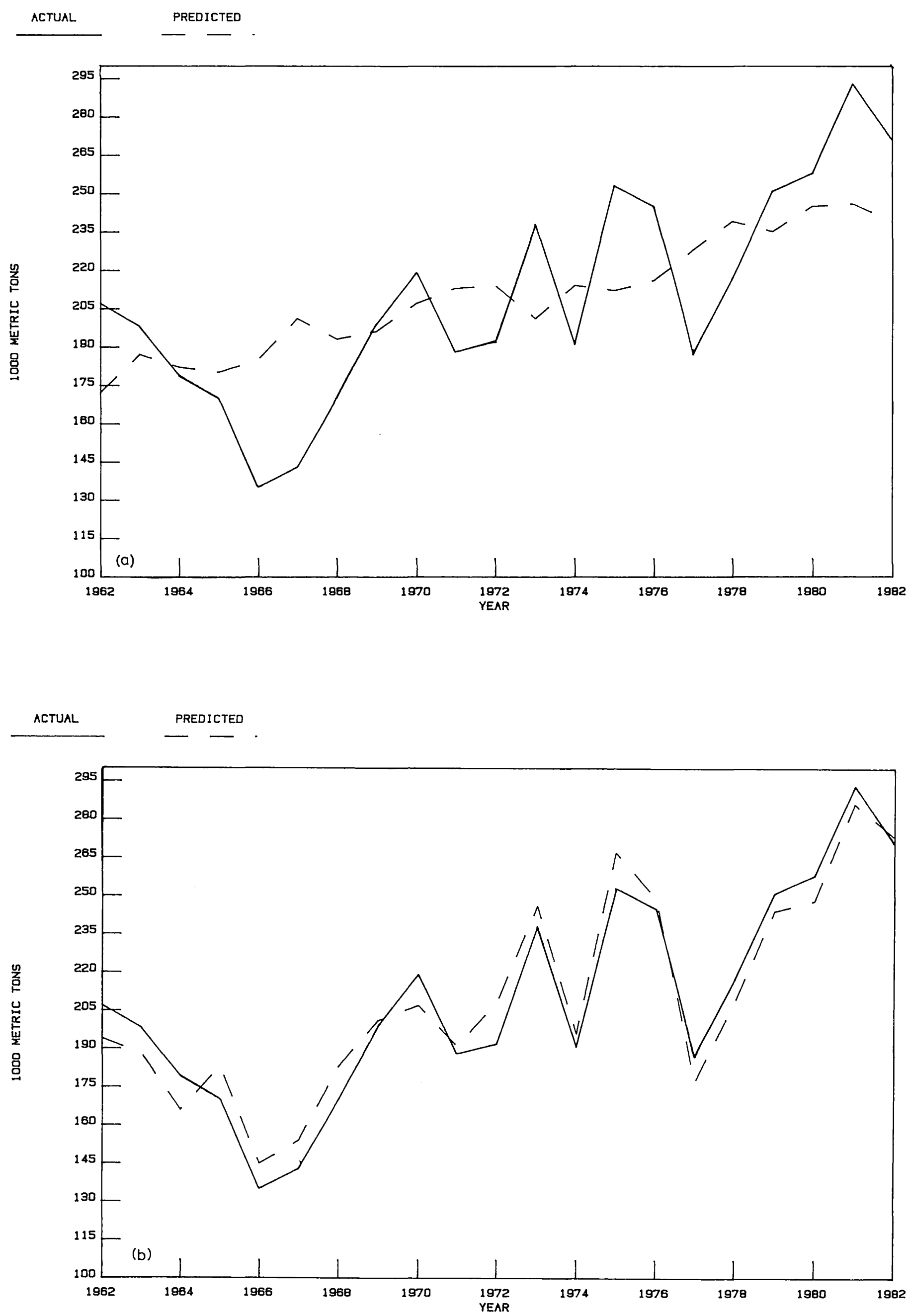
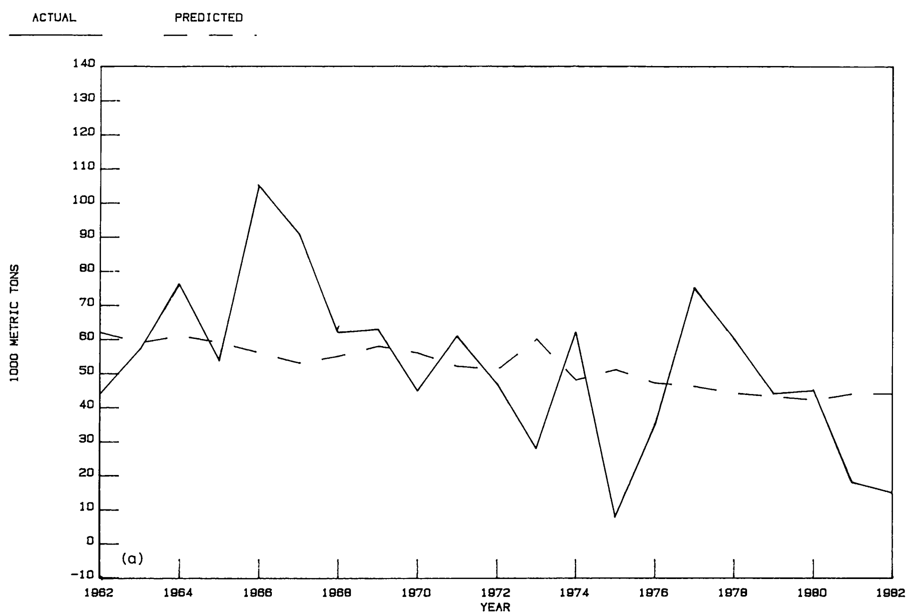


Fig. 2. Domestic disappearance of rice in Spain: (a) rice consumption standard model; (b) rice consumption policy model.



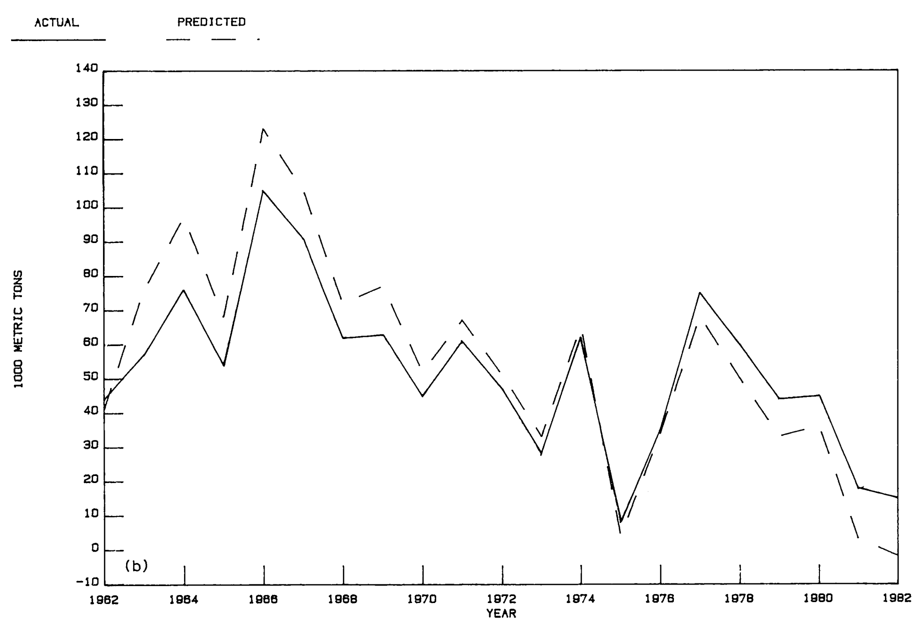


Fig. 3. Net Spanish exports of rice: (a) rice exports standard model; (b) rice exports policy model.

Conclusions

Although the policy model appears to provide a better description of the Spanish rice than the other models, it cannot be concluded that it is the 'correct' model. However, structuring the model to more accurately portray the intervention of the state is a promosing approach for this particular market. The model could clearly be improved if more information on the policy-making process were available. For example, interviews with Spanish officials would be very useful in understanding why acreage shifted in 1977, what criteria were used to set prices, how stocks were handled, etc. The principal weakness of the policy model is that it is largely inferred from possibly unreliable statistical evidence. Nevertheless, the strength of most of the statistical relationships and the accuracy of the historical predictions are indications of the potential usefulness of this type of model specification.

This study was undertaken initially to project the changes that would occur in the Spanish rice sector following accession to the EC. If a policy model such as the one presented here is, in fact, an accurate historical representation of this sector, such predictions become problematic. As a member of the EC, the Spanish government will have to adopt the rice regime of the Common Agricultural Policy, which is quite different from historical Spanish rice policies. SENPA will not disappear, but its functions will change to conform with those of the other intervention agencies in the EC. Prices will be set in Brussels on the basis of community-wide concerns. In place of the Spanish monopoly, a network of private traders will handle both internal and external trade subject to EC regulations including subsidies for rice exports. In these circumstances the old policy model is no longer valid and a new policy model reflecting the current situation is needed to evaluate the effects of Spain's entry into the EC. The problem, of course, is that no such model can be estimated because there are no degrees of freedom.

This last conclusion is an extension of the criticisms raised against the standard procedure of varying exogenous policy parameters in structural econometric models to evaluate the effects of policy changes. For Spain, the rules of the game have changed dramatically and inferences drawn from historical data may not be of much use in predicting future developments. Fortunately, there are alternative approaches that can be used to shed light on the problem. For example, drawing on the expert knowledge of individuals familiar with this sector, a researcher could simply infer the most reasonable values of supply and demand elasticities, and use these estimates to project the most likely changes. Some method for making composite or consensus projections based on a combination of statistical evidence and a wide range of expert opinion might also be developed. Perhaps technical information and mathematical programming could be used to synthesize the economic relationships. The use of a wide variety of technical, institutional and other information may be the only way to understand the implications of radical policy changes such as the ones taking place in Spain today.

Consider the case of the Spanish rice market following accesion to the EC. Recent data indicate that rice acreage in Spain has risen to a new level after a dramatic fall in 1983 (USDA, 1987). The average for 1984–86 was 75 000 ha compared with about 68 000 ha for 1977–82. If one attributes this change entirely to the anticipated price increase following accession, an implicit acreage response elasticity can be inferred. The change in acreage represents an increase of about 10%, while the price increase noted earlier is about 32%. This suggests an elasticity of about 0.31 which is consistent with the value of 0.29 chosen by Herruzo (1985, p. 271). On the basis of equation (14), the elasticity of domestic disappearance is estimated to be about -0.13. On the basis of these elasticities and using average figures for the early 1980's (excluding 1983 because it is an outlier), it is estimated that Spanish rice poduction increased by 10% as a result of accession while per capita disappearance fell by about 4%. As a result of these changes, the estimated exportable surplus was about twice what might have been expected in their absence, although the projected average of about 65 000 metric tons is not radiaclly different from levels reached in the 1970's.

These conclusions on the implacations of EC membership for the Spanish rice sector should be seen as preliminary. They should be adjusted and modified in light of additional information and the insight of knowledgeable individuals. For example, further information on the kinds of rice varieties used in Spain and the tastes and preferences of consumers in Spain's export markets might lead to modification of projected export levels. In addition, an assessment of the effects of the institutional change from a state monopoly to a network of private traders is needed to refine the projections presented here. In many cases, this process of bringing together a wide range of information may be the only way to answer the practical policy questions with which the applied economist is frequently faced.

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