ECONOMETRIC MODELLING for AGRICULTURAL POLICY ANALYSIS and FORECASTING

Between Theory and Reality

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ABSTRACT

The inherent characteristics of the agricultural sector, like price instability, time lag between decisions and the resultant outputs, and risk and certainty, necessitate the development of econometric models for policy analysis and forecasting. The need for accurate forecasts and an empirical tool for policy evaluation are reinforced as the sector undergoes structural changes and becomes complex due to trade liberalization, globalisation, technological advances, and consumers' changing tastes and preferences. Econometric models have long been viewed as a valuable aid to deal with this apparent complexity.

The contribution of econometric models to the analysis of the agricultural sector, in Malaysia and in other countries, has been significant. The models generate quantitative forecasts and enhance the ability of those involved in planning and policy-making in evaluating the effects of policy changes. The models, however, have limitations since models represent an abstraction of a rather complex real world. This lecture therefore attempts to discuss the theory and the reality of the econometric modelling of agricultural commodity for policy analysis and forecasting.

Agricultural commodity markets are complex, often with many actors and sectors involved in production, consumption, inventory holding, capacity formation, and trade, and also the competitive nature of the overall market structure. Although the theoretical framework of econometric modelling is easy, the reality can be challenging since the empirical content of the model must not only reflect the essential structure of the model, but also the behaviour of government in imposing policy interventions. Given the enormity of the task, model applications should be improved in the direction of employing newer approaches to market and policy simulation, and forecasting works should embody new probabilistic approaches for evaluating risk impacts. Continued work is also needed on the means of incorporating the effects of changing input prices, such as energy and technological developments on the supply side, and new products and changing tastes on the demand side.

INTRODUCTION

Agriculture has been and will always remain an important sector of a national and global economy. It provides the ultimate source of essential food and fibre for the population. No industrial substitutes have yet been found to replace food requirements. Thus the long-term survival of mankind will depend on the sustainability of the agricultural sector. Considerable changes in the characteristics of the sector, however, have occurred, both domestically in Malaysia and internationally in other countries, which now demands different policy and strategies as to its development. Not only are the changes taking place more rapidly, and that the pressures for further changes in agriculture and related industries are multi-dimensional, but there is also the fear of increasing uncertainties in globalisation. Accordingly, it is increasingly difficult to predict with any certainty the environment for agriculture that might prevail in the future. This uncertainty is compounded by the inherent characteristics of the agricultural sector, like price instability and volatility, time lag between decision and the resultant outputs, as well as a web of policy instruments that regulate the sector.

Being a small and open-economy that is increasingly dependent on the performance of more industrialized countries, Malaysia constantly has to adjust her policy in view of external factors and structural changes in the economy. Thus there is a need to analyse the effect of different agricultural and macroeconomic policies, both locally and globally, on agricultural production, consumption, trade, farmers' income and the environment.

Economic modelling has long been viewed as a valuable aid to the evaluation and selection of policy analysis and forecasting. Models can be employed to generate quantitative forecasts and to evaluate the effects of alternative decisions or strategies under the direct control of policy makers. Models can also offer a framework for conducting laboratory experiments without directly influencing a commodity or the agricultural economy. It offers a basis for re-evaluating the judgement of analysts and policy makers. Hence, the models can be used for projections of agricultural commodity and impact analyses of alternative policy scenario. In the light of the above scenario, this paper attempts to discuss the theory and the reality of issues of modelling the Malaysian agricultural commodity for policy analysis and forecasting.

The paper is outlined as follows. The first section provides a brief description on the need for agricultural policy analysis and forecasting. This is followed by a remark on the need for Malaysian agricultural sector models. The theoretical framework of econometric modelling is then presented. This leads to a discussion on the application and the reality of econometric modelling in the Malaysian agricultural commodity. The last section proposes the direction of agricultural commodity modelling.

THE NEED FOR POLICY ANALYSIS AND FORECASTING

The late 1990s and the new millennium marked a significant shift in the Malaysian economy as a result of the financial crisis that hit the country as well as other Asean economies. The crisis has been interpreted as one of the major dimensions of globalisation process that is engulfing the world trade and economy. The crisis created a number of realizations and lessons that were significant in shaping up the country's future agricultural policy. One of the major realizations and lessons learned from the crisis was that the agriculture sector was the country's saviour from an almost complete debacle as has happened in the neighbouring countries, particularly Thailand and Indonesia. The country's balance of payment was saved by the agricultural exports which enjoyed high prices during the crisis period; in particular palm oil. In 1998, the overall GDP growth rate was –5.1% while her food and agribusiness growth rate grew by 8.5%. The other realization was the high import bill for food amounted to RM12 billion in 1998. In 2005, the import bill for food increased to RM13.9 billion. The import bill was not only high, but its composition reveals Malaysia's heavy dependence on feed stuff to support her livestock industry, her inability to produce enough cereals for food and feed meal, dairy products and meat. These realizations have prompted the Malaysian government to revive the role of the agricultural sector after it has been neglected during the country's industrialisation process in the 1980s and 1990s. Under the Ninth Malaysia Plan (2006-2010), agriculture is designated to be the third engine of growth. In short, the agricultural sector is given special emphasis for its revitalization and sustainability.

With the government's policy revival in the agricultural sector, it would be interesting to see how this sector will perform under the industrialization of the country's economy as well as the globalisation development that is affecting the trade and domestic market. An understanding of the sector's progress and development would provide the guiding rationales as well as strategies for its future growth. Despite the two National Agricultural Policies (NAP I and II), and currently under the Third National Agricultural Policy, the support and incentives that have been provided, the sector has not generated the growth and development of the downstream activities. The industrialization process affected the agriculture sector through a tighter competition for the same pool of resources, namely land, labour and capital. The globalisation process also affected this sector through a more liberal trade environment; i.e., lesser protection and a stiffer competition from cheaper imports and more efficient producers.

The relevant questions from the above scenario are: (1) How has the agricultural sector performed under the third National Agricultural Policy?; (2) What is the impact of globalisation and trade liberalization on the sector?; (3) What are policy issues facing the sector?; (iii) How will the sector perform under alternative policy scenario?; (4) Can we forecast the supply, demand and prices of agricultural commodities; and (5) What are the policy implications and strategies to enhance the growth and contribution of the sector? Policy analysis and forecasting can guide policy makers and researchers to the above questions with some evidence or explanations to derive some plausible answers. The model enhances the ability of those involved in the planning and policy making in evaluating the effects of policy changes and assists them in the development of long-term projections of changes in the Malaysian agricultural sector.

THE NEED FOR AGRICULTURAL COMMODITY MODELS

Over the last decade we have seen the introduction of policy instruments which have had a complex impact on production and trade decisions of an agricultural commodity (consider, for example, changes in imports quotas, tariffs, and partially decoupled subsidies). Various economic (such as exchange rates) and non-economic factors (such as weather extreme) may also influence the performance of the commodity and hence the agricultural sector. These have led to the need to increase the accuracy of policy analyses and market forecasts, an objective that can be easily achieved with the potential of present-day quantitative economic models. The estimated models were thought to be useful for a wide range of problems: analysis of proposed policies, evaluation of existing policies, forecasting, and improved understanding of the economy. Although the models by themselves are not able to predict market development consistently, they tend to narrow the range of likely outcomes, and thus reduce the risks and uncertainties of investing and trading in the agricultural commodities.

Economic models also made it possible to evaluate the costs and benefits of alternative market policies. Models provide not only answers to 'what-if' questions; they also inform the analysts the economic costs and benefits associated with the question. Models increasingly became instrumental during recent decades in shaping domestic markets policies particularly in the agricultural sector.

Some examples of the kinds of economic modelling analysis that can be performed include the following:

1. Market forecasting analysis concerns the short, medium or long run forecasting of commodity quantities and prices. Sometimes this forecasting is of a conditional or "what-if" nature.
2. Policy simulation analysis considers how markets or industries react to changes in national or international policies, also on a "what-if" basis.
3. Market stabilization analysis involves finding those control mechanisms or forms of market organization which lead to more stable price or equilibrium positions.
4. Market planning analysis relates to the projecting of long run outcomes, depending on the policy problems or market strategies of interest. Commodity investment analysis is of this type.
5. Supply restriction analysis requires that a probabilistic theory describing the possibilities of sudden supply or import disruptions be integrated with domestic market analysis.
6. Agricultural process analysis explains the influence that farm level decisions, technology, aggregate demand and prices have on agricultural output.
7. Industrial process analysis describes the relationship that exists between national activities, technical transformation processes within industries, and commodity input demands.
8. Analysis of spatial flows requires the application of spatial economic theory at the commodity level so that the relations of demand, supply and transportation costs to commodity trade flows can be determined.
9. Economic growth analysis can solve problems of planning for growth, where commodity exports represent the 'engine' or primary sector of country growth.

The task of the commodity modeller is to perform any of the above analyses to meet the needs of the model user. No single model, however, can meet all modelling purposes. This sometimes requires that entirely different kinds of quantitative methodologies be employed to meet these different purposes. Various kinds of economic modelling methodologies that are normally employed are presented in Table 1.

In studies in which the entire economy and, particularly, linkages between sectors are of interest, input-output analysis has been used. In other studies where the objective has involved identification of a sector's structure, various econometric approaches have been applied. To simulate the effect of new policies upon a sector, mathematical model has normally been utilised. Large-scale, price-exogenous, linear programming models have been used extensively by agricultural economists to simulate the impact of farm policies upon the agricultural sector.

It is relatively easy to present a model and analyse the results. What is also important is to give sound arguments favouring a chosen modelling philosophy and methods. For this reason, in modelling works, normally, one third of the time is devoted to the review of literature and evaluation of the theoretical and methodological basis of the model, one third is devoted to the presentation of the model structure, and one third is devoted to the application of the model. In this lecture, our interest is in the econometric modelling of the Malaysian agricultural commodity. This involves, mainly, estimation of parameters of behavioural equations which derive from economic theory, such as demand, supply, and price functions.

Econometrics is the field of economics that concerns itself with the application of mathematical statistics and the tools of statistical inference to the empirical measurement of relationships postulated in economic theory. The theoretical basis of the econometric approach is most often the same as in optimisation approach: producers are maximising their profits and consumers

Table 1 Economic modelling methodologies

Methodologies	What is the purpose of the methodology?	What quantitative method is used?	What economic behaviour is specified?
Market Models	Demand, supply, inventories interact to produce an equilibrium price in competitive markets	Dynamic micro econometric system composed of difference or differential equations	Interaction between decision makers in reaching market equilibrium based on demand, supply inventories, prices, trade, etc
Spatial Equilibrium and Programming Models Linear and Quadratic Programming	Spatial flows of demand and supply and equilibrium conditions assigned optimally in equilibrium depending on configuration of transportation network	Activity analysis of a spatial and/or temporal form. Degree of complexity depends on endogenously and method of incorporating demand and supply functions	Interaction between decision makers in allocating shipments (exports) and consumption (imports) optimized through maximizing sectoral revenues or minimizing sectoral costs
Mixed Integer Programming	Spatial and temporal equilibrium embodying production-process, transportation, and project investment components	Activity analysis involving spatial and temporal optimization but also including integer (0,1) variables to represent capacity additions	Interaction between decision makers in finding minimum discounted costs of meeting specific market requirements, i.e. project selection
Optimization Models	Supply and demand analyzed in relation to optimal resource exhaustion over time and cartel behaviour	Dynamic micro econometric system featuring formal cartel-fringe models such as that of monopoly, Stackelberg or Nash Cournot	Interaction between decision makers in optimizing resource allocation and prices over time in non-competitive markets involving bargaining activity

Table 1 Economic modelling methodologies (continued)

Systems Dynamics Models	Demand, supply, inventories interact to produce an equilibrium price emphasizing role of amplifications and feedback delays	Dynamic micro econometric differential equation system which features lagged feedback relations and variables in rates of change	Interaction between decision makers in adjusting rate of production to maintain a desired level of inventory in relationship to rate of consumption
Input-Output Models	System regarded as process that converts raw materials into intermediate and final products via intermediate processes	Input-output model combined with macro economic framework or disaggregated raw materials balance framework	Interaction between non-fuel and fuel commodities and macro markets in reaching materials and energy balance including supply-demand determination

are maximising their utility under given constraints. The assumption of profit or utility maximisation is at least indirectly embedded in econometric commodity sector models. Explicit optimisation and formulation of a global objective function (which is the case in most optimisation models) are not needed, however, in econometric models. The optimisation conditions can be formulated as a system of econometric simultaneous equations whose parameters are estimated by simultaneous equation methods of standard econometrics. Duality theory can also be used when formulating the equations, given the assumption that producers and consumers maximise their profit and utility, respectively. An economic equilibrium is assumed, i.e. marginal profits of different products are equalised. The system of equations is solved in such a way that the equilibrium conditions are satisfied. Econometric equations are quite flexible and different functional forms and sets of different explanatory variables can be tested. One can easily find generally accepted statistical tests and other validation procedures in the literature to base on. Econometric models are also flexible in the sense that they can mimic dynamic patterns by introducing lagged variables.

Econometric analyses on agricultural policy instruments have always constituted one of the most important fields of inquiry for agricultural economists. Attention paid to this area of research has grown apace in the last few years, essentially for two reasons. The first is connected with the advances in economic theory on the modelling of agricultural sector and its econometric translation. In fact, the fundamental contribution of econometric models in this area lies precisely in having set up models that can reproduce the impact of agricultural policy instruments on the decisions of agricultural producers, and this has been possible with the progress in analyses applied to the theory of production. The second reason is connected with the recent developments in agricultural policy and, in particular, the trade liberalization and globalisation.

THEORY OF ECONOMETRIC MODELLING

From a theoretical view point, a commodity model is a quantitative representation of a commodity market or industry; the behavioural relationships included reflect demand and supply aspects of price determination as well as other related economic, political and social phenomena. Hence most commodity models are composed of a number of components which reflect various aspects of demand, supply and price determination (Figure 1). Modelling of a commodity markets entails integrating all of the above components into the overall markets or industry. As mentioned earlier, implicit in the assumption is that producers are maximising their profits, and consumers are maximising their utility under given constraints.

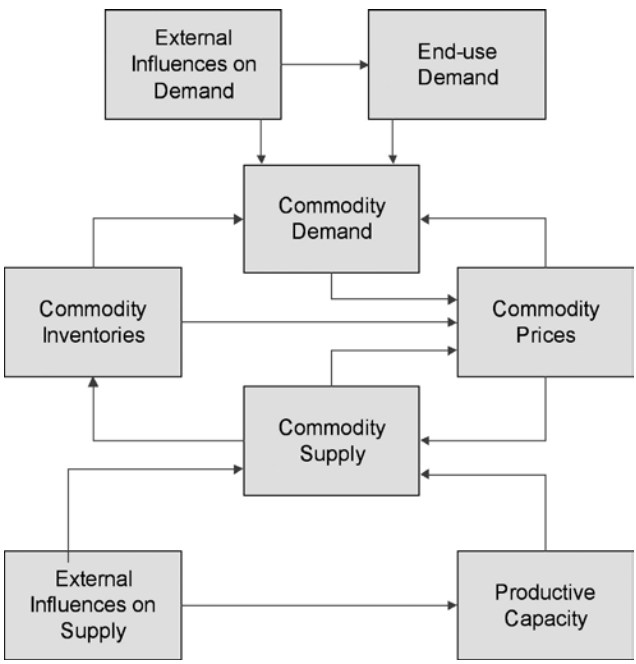

Figure 1 Schematic representation of a commodity model

As shown in Figure 1, demand for a commodity depends on its own and other commodity prices as well as external influences such as income or economic activity. Commodity supply depends on prices as well as external influences such as cost of production, whether, or agronomic factors. Prices are simultaneously determined by demand supply. Inventories normally exist on the demand and supply sides of the market and these are held for precautionary, transaction or speculative motives. Depending on the elasticity of demand and supply, inventories play a role in price adjustments. The approach that is taken to construct an econometric commodity market model resembles that of other economic models: (1) Determination of modelling purposes; (2) Selection of model structure; (3) Specification of relationships; (4) Estimation of parameters; (5) Validation; and (6) Model solution or simulation.

The selection of the structure of a commodity model reflects not only the formal methodology employed including model specification, estimation and simulation, but also the attributes of the commodity market or a particular commodity problem to be analysed. Examples of such attributes include the non-competitive nature of a market, the presence of international stockpiles, or a range of tariff or non-tariff trade barriers. Also relevant in this context is the empirical scope of a model. While almost all econometric commodity models are temporal, some of these also embody important spatial characteristics. The degree of disaggregation is also significant particularly with respect to commodity end-uses.

Crop Model: An Example

Figure 2 presents a general structure of a crop model. Each crop model, however, has its own particular structure somewhat at variance with the general.

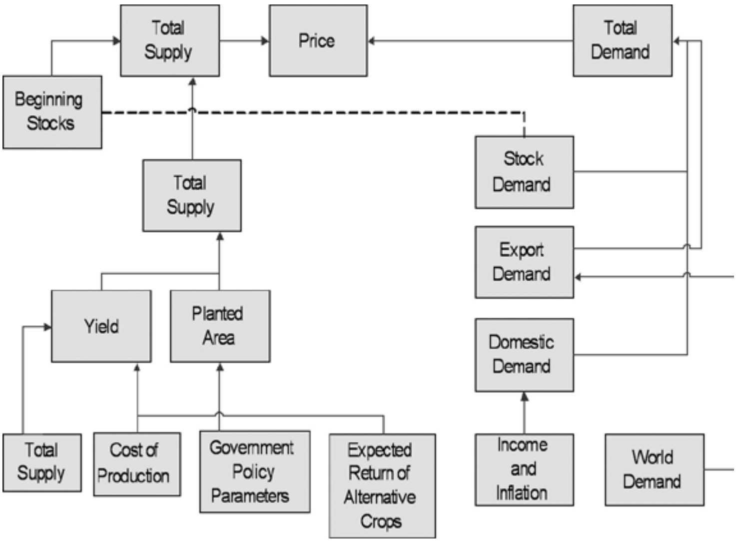

Figure 2 General structure of a crop model

Source: Mad Nasir *et al. (1993e)*

The structure of commodity models can be summarized in the following equations, although much more complex structures are used in practice:

$$Q_t = q\,(Q_{t-1}, P_{t-i}, P^c_t, N_t, Z_t)$$

$$D_t = d\,(D_{t-1}, P_t, P^s_t, A_t, T_t, X_t)$$

$$P_t = p\,(P_{t-1}, I_t)$$

$$I_t = I_{t-1} + Q_t - D_t$$

Where	Q	=	commodity supply
	P_{t-i}	=	prices with lag distribution
	P^c	=	prices of competing commodities
	N	=	agronomic factors
	Z	=	policy variables influencing supply
	D	=	commodity demand
	P	=	commodity prices
	P^s	=	prices of substitute commodities
	A	=	income or activity level
	T	=	technical factors
	X	=	policy variables influencing demand
	I	=	commodity inventories

Supply is explained as being dependent on its own prices and prices of competing commodities as well as underlying productivity factors such as agronomic influence, and a possible policy variable. A lagged price variable is included since the supply process is normally described using some form of the general class of distributed lag functions. Other possible influencing factors and the customary stochastic disturbance term are omitted here to simplify presentation. In the case of industrial crop such as palm oil and natural rubber, the supply equation may be broken into two equations explaining smallholder and estate supplies.

Demand would depend on price, economic activity, prices of one or more substitute commodities, possible technical influence such as the growth of a synthetic substitutes, and relevant policy variables. For export commodities, a modification of this equation is necessary since domestic demand and exports do not depend on the same set of explanatory variables. Thus the demand equation may be broken into two equations explaining domestic and export demand.

Prices are explained by inventories. This equation is sometimes inverted to explain inventory demand. Although the price relationship is a function of inventories, any final specification adopted would depend on whether the underlying price structure reflects a flow adjustment, a stock adjustment, or a stock-flow adjustment process.

The model is closed using an identity which equates inventories with lagged inventories plus supply minus demand. Where the price equation is inverted to represent inventory demand, the identity can be recognized as the equivalent supply of inventories equation.

The above model requires its variable to be classified as endogenous variables: Q, D, P and I; and exogenous variables: P^c, P^s, A, N, T, X, and Z. X and Z are also known as instrument or policy controllable variables.

APPLICATIONS IN THE MALAYSIAN AGRICULTURE

Applications of the econometric modelling in the Malaysian agricultural commodities are numerous. However, in this paper, only studies conducted by the author, as presented in Table 2, are mentioned. The studies concentrated on the Malaysian agricultural primary commodities, namely, palm oil, rubber, cocoa and sawn timber, and food commodity, rice. In general, the models were developed to serve three purposes: (1) understanding and determining the market structure relationship; (2) analysis and prediction of the impacts of policy instruments which involve policy simulation analysis; and (3) forecasting commodity variables (supply, demand and prices).

Policy simulation analysis helps to answer “what if” questions about past or future commodity market responses to particular policies. Short-term forecasting has been concerned with commodity prices. Uncertainty surrounds the fluctuations in the price variable, due to sudden changes in economic activity relative to commodity inventory levels. Long-term forecasting has been performed to gain knowledge about supply response and future supply availability as well as prices.

Table 2 Selected applications of agricultural commodity models by the author

Author	Commodity	Model Structure	Application
Mad Nasir et al. (1988)	Palm oil	System of equations	To determine factors affecting palm oil prices
Mad Nasir et al. (1990)	Natural rubber	Single equation and time-series	To forecast natural rubber prices using a composite model
Mad Nasir (1991)	Natural Rubber	Mutivariate	To forecast natural rubber prices using a MARMA model
Mad Nasir et al. (1992)	Cocoa	System of equations	To determine factors affecting cocoa prices
Mad Nasir (1993)	Cocoa	System of equations	To determine the effect of import liberalization on the Malaysian cocoa beans
Mad Nasir and Fatimah (1993a)	Palm oil	System of equations	To investigate the market structure of palm oil
Mad Nasir and Fatimah (1993b)	Palm oil and rubber	System of equations and time-series	To compare techniques in forecasting palm oil and rubber prices
Mad Nasir and Fatimah (1993c)	Palm oil	Single equation and time-series	To forecast monthly palm oil prices
Mad Nasir and Zainal (1993)	Palm oil	Vintage model and single equation	Projection of palm oil supply using a vintage approach
Mad Nasir et al. (1993d)	Cocoa	System of equations	To investigate the market structure of cocoa
Mad Nasir et al. (1993e)	Agricultural sector	System of equations	To conceptually develop multi-commodity model

Table 2 Selected applications of agricultural commodity models by the author (continued)

Mad Nasir and Mohd. Shahwahid (1994)	Sawn timber	System of equations	To determine the economic and welfare impacts of export levy on sawn timber
Mad Nasir and Fatimah (1994)	*Palm oil*	*System of equations*	*To develop forecasting model for palm oil prices*
Mad Nasir *et al.* (1994)	Palm oil	System of equations	To determine the import demand for palm oil
Mad Nasir and Mohd. Shahwahid (1995)	Sawn timber	System of equations	To determine the export demand for sawn timber
Mad Nasir (1996)	Cocoa beans	System of equations	To analyse the imposition of export levy on cocoa beans
Mad Nasir (1997)	Palm oil	System of equations	To investigate the effect of export duty reduction on palm oil
Mad Nasir *et al.* (1997)	Palm oil	System of equations	To investigate the effect of export duty reduction on palm oil incorporating the world market
Mad Nasir *et al.* (1988)	Agriculture sector	System of equations	To develop the Malaysian agricultural sector analysis model

Table 2 Selected applications of agricultural commodity models by the author (continued)

Mad Nasir and Webb (1998)	Food	System of equations and time-series	To generate food outlook
Mad Nasir and Tengku Mohd Ariff (2005)	Rice	System of equations	To investigate the impacts of AFTA and WTO compliance
Lin and Mad Nasir (1992)	pork-hog and beef-cattle	System of equations	To investigate the dynamic characteristics of the US red meat industry
Mohd. Shahwahid and Mad Nasir (1993)	Sawn timber	System of equations	To determine the impact of export levy
Yusoff and Mad Nasir (1993)	Natural Rubber	System of equations	To develop natural rubber production and trade model

Understanding Structural Relationship

In view of the economic importance of the Malaysian agricultural primary commodities, studies on the relationship of the major economic variables of the commodities are useful for they will provide a framework for policy impact analyses. For this purpose, the author has developed the market models for palm oil (Mad Nasir *et al.* 1994), rubber (Yusoff and Mad Nasir, 1993), cocoa (Mad Nasir *et al.* 1992), sawn timber (Mad Nasir and Mohd Shahwahid, 1995) and rice (Mad Nasir and Tengku Arief, 2005).

The models were developed to understand the behavioural interrelationship of the economic variables of the commodities (supply, demand, price and inventory). Where possible and relevance, the supply was categorised into estate and smallholders sectors, and the demand was into domestic utilization, exports and imports. Accordingly the prices were classified into domestic, export and import prices. The parameter estimates were useful for a wide range of problems such as improved understanding of the behavioural structure of a commodity, analysis of proposed policies, evaluation of existing policies, and forecasting.

Based on the author's experience, construction of commodity models is not an easy process. International commodity markets are complex organisms, often with many actors and sectors involved in commodity production, consumption, inventory holding, capacity formation, trade, etc. Models often cannot duplicate this complexity and detail. Given the enormity of the task, good modelling requires simplification and abstraction to represent the essential elements of the system under examination. Of importance not only is the detailing of individual relationships concerning say consumption or prices, but also the competitive nature of the overall market structure. The modelling problem can be challenging since the empirical content of the model must reflect the essential structure of the model. It includes not only the structure of the internal supply and demand, but also the behaviour of government in imposing policy interventions.

The time span of the model of interest must be decided. Is the market behaviour to be analyzed or forecast of a short, medium or long-term nature? Depending on the term, different temporal aspects of the specification must be considered. There is also the need to re-examine conventional notions about adjustment mechanisms which move commodity markets towards equilibrium. Price may not be the result of competitive adjustments; consequently market structures reflective of monopolistic competition must be investigated. Some markets may also never attain equilibrium in the sense that supply always equals demand at different points in time; thus the disequilibrium characteristics of the market must be modelled. Finally, the market represents more than an economic mechanism. Other information needs to be introduced, which relates to the institutions and the organization of the market, the behavioural patterns of industries and firms, and the government policies affecting the market.

Policy Impact Analyses

Malaysian agricultural primary commodities, in particular palm oil, rubber and cocoa, have been plagued by market instability which is reflected by their export performance and price fluctuation. This market instability becomes more apparent under strong competitive environment especially under the trade liberalization regime. The performance of the commodities is also subjected to changes in the exchange rate policy. The vulnerability of the commodity market to various policy instruments warrants a study to evaluate the impacts and proposed alternative policies. Studies conducted by the author and his colleagues, (Mad Nasir (1993) on cocoa; Mad Nasir and Mohd Shahwahid (1994) on sawn timber; Mad Nasir (1997) on palm oil; Mad Nasir *et al.* (1997) on palm oil; Mad Nasir (1998) on cocoa; Mohd Yusoff and Mad Nasir (1993) on rubber; and Mad Nasir and Tengku Arief (2005) on rice), were able to determine and simulate, where relevance to the commodity under study, the impact of our export duty, import tariffs of the importing countries, and exchange rate policy on the production, export, prices and imports as well as providing alternative policies.

The above models are commodity specific. Although they are elegance and can be utilised to evaluate policy instruments, they are partial equilibrium in nature. Hence to capture the dynamics of linkages among agricultural commodities, the author has also developed the Malaysian Agricultural Sector Analysis (MASA) model, a multi-commodity, multi-sectoral forecasting and policy simulation model of the Malaysian agricultural economy (Mad Nasir *et al.,* 1998). The model contains 17 commodities, including oil palm, natural rubber, cocoa, pepper, coconut, rice, tobacco, pineapple, vegetables, fruit, beef, mutton, eggs, broiler, swine and fishery and forestry. Where applicable, the production is divided into estate and smallholder sub sectors. Each commodity is linked to others through competition for land and, in some cases, substitution in demand. Thus when the equilibrium of one commodity is obtained, it reflects simultaneous equilibrium in all other commodities. The Model can be applied for projection, policy simulation analysis and policy guidance.

Forecasting

The prices of the Malaysian agricultural primary commodities continue to exhibit significant variability and volatility overtime which make forecasting almost a formidable task. Under such a situation a reliable forecast is vital to the market participants to minimise uncertainties and hence losses. The author has conducted studies on short-term forecasting of rubber and palm oil prices, utilizing econometric technique, time-series technique or combination of both called composite method (Mad Nasir and Fatimah (1990) for rubber prices using econometric, time-series, and composite model; Mad Nasir (1991) for rubber prices using MARMA model; and Mad Nasir and Fatimah (1993) and (1994) for palm oil prices using econometric, time-series, and composite model). Studies for long-term projection have also been conducted by the author (Mad Nasir and Webb, 1988; Mad Nasir *et al.,* 1998).

The studies found that although time-series has been proven to be an efficient technique for short-term forecasting, the technique only involves investigating the past price behaviour in terms of certain preidentified patterns such as cyclicality, seasonality, and trend. Hence this method lacks sound theoretical foundation and does not provide the economic explanation of its forecasts. An econometric model provides a better alternative as it has the properties of being able to incorporate the structural relationship between the variables into the equation and reflect its influence on the forecasted variable. Studies by the author also indicate that the combination of econometric and time-series approaches into a composite model yields more efficient forecast. Thus studies on palm oil and rubber imply that forecast taken from individual models are not likely to provide the user with the most accurate information. The output might be better off to combine the forecasts since it include a structural explanation of that part of the variance of palm oil and rubber prices that can be explained structurally, and time-series explanation of that part of the variance of the price that cannot be explained structurally.

REALITY IN ECONOMETRICS MODELLING

This section discusses the reality in the econometric modelling of agricultural commodities. Although the experience of the author is in the Malaysian agricultural commodities and the red meat industry in the United States (for his PhD thesis), the reality of issues are universal.

Econometric modelling works are not a straight forward process. When the author did his PhD thesis, the first time that he encountered econometric modelling, he took almost one year trying to figure out what he was trying to model. He estimated, re-estimated, and re-estimated the models. To obtain the final estimated equation, he had to evaluate the equation both in terms of economic and statistical criteria. Finally, after a long discussion with his supervisory committee, he established the following criteria:

i. Retain a variable which is statistically significant and conform with *a priori* expectation of economic theory;

ii. Retain a variable, although is not statistically significant, but conform with *a priori* expectation of economic theory; and

iii. Delete a variable which is statistically significant, but does not conform to *a priori* expectation of economic theory.

Since the above criteria was established in 1985, more than twenty years ago, it must only be used as a guide in today's modelling works as there are criteria and statistical tests that that have been developed since then.

Parameter Estimation

Many econometric results are fragile. Estimates of parameters are sensitive to changes in the sample as well as to changes in the model specification. The author's experience with this problem occurred more than 20 years ago during his PhD works, when he decided to refit a supply of beef-cattle equation to illustrate alternative models (Mad Nasir, 1985). The alternative model required an additional lag, and it was found that when the first data point was dropped, the coefficient of price changed from positive with a large t-ratio to negative with a small t-ratio. It turned out that the "significant" price elasticity of supply in the original model was dependent on the first data point.

What is equally problematic in econometric and optimisations models is the estimation of model parameters. For example, signs of elasticity parameters may depend on the length of time series data used in estimation. This is problematic, since the price elasticity of demand, for example, must be negative for downward sloping demand functions. In addition, the price elasticity of supply should be positive because of theoretical consistency. In simulation exercises, sometimes, the model parameters have been set using expert knowledge or adopting parameter estimates from modelling exercises in some other countries. This is understandable because of estimation problems or because of the lack of resources available for parameter estimation. Taking parameters directly from other studies and countries, however, should not be accepted as a general practice.

Modelling Framework

Modelling framework normally places heavy weight on the correctness of the model, the maintained hypothesis, since the properties of the estimators and hypothesis tests are conditional on the model. Econometricians assumed that they could correctly classify variables as endogenous and exogenous and could correctly specify the restrictions on the model. The latter assumption means that each equation of the model contains the relevant variables (those with non-zero parameters) and that each equation correctly excludes irrelevant variables. The exclusion restrictions in a simultaneous system of equations have been the principal way of determining the degree of identification, and a simultaneous equations estimator will not be a consistent estimator unless the equation(s) being estimated includes all relevant variables. In other words, the traditional approach in econometrics assumed that the true data generating process is known and correctly modelled. Thus, emphasis was placed on obtaining optimal estimators under the assumed data generating process.

This carried over into empirical applications in agricultural economics. Much published research has emphasized the selection of the estimator assuming the model was correctly specified. It has been rather uncommon to discuss model selection procedures or to go beyond a rather superficial evaluation of the quality of results. The classification of variables as endogenous and exogenous has typically gone untested; if ***t***-ratios are large, signs of coefficients logical, etc., the model has been assumed to be adequate.

In the typical research scenario, however, the correct model specification is uncertain. The analyst has a research problem, observational data, and has access to relevant theory and previous research. But, there are often competing theories, and published results can differ substantially. The true data generating process is unknown, and numerous plausible representations of the data exist (Hendry, 1995). Consequently, there is uncertainty about the appropriate inference methods, and an estimator, which is optimal for one conceptualization of the data generating process, may be seriously biased in practice.

The problem is even worse for forecasting. In this case, the model that was assumed valid for the sample period must be assumed to remain valid for the forecast period. Moreover, ancillary forecasts of the exogenous variables are required in order to forecast the endogenous variables. As already noted, the exogenous variables are not explicitly modelled in the typical structural model, but they are usually stochastic variables with unknown data generating processes. A structural model is potentially most useful for forecasting when a major change occurs in one of the explanatory exogenous factors, such as a large reduction in production. But, this is precisely when estimated models have failed.

There are two problems. One is the quality of the estimates of the parameters. The event being analyzed may have caused a structural change; the parameters do not remain invariant in face of the change. Thus, estimates based on the historical time series are not relevant to the new conditions. Even if the structure has not changed, the historical sample may not have provided adequate variability in the explanatory variables to obtain precise estimates of the relevant parameters. Also, a linear functional form which seemed adequate for the historical sample may turn out to be wrong in light of the larger range of variability in the data.

The second problem is that it is often impossible to forecast the magnitude of the realized change in the explanatory variables. The high palm oil prices in 1998 were not forecast accurately in the prior year because the relevant levels of supply and demand factors were not accurately forecast. The actual production was lower than expected, and the export demand turned out to be higher than expected. Thus, ending stocks for the 1998 were small.

Clearly, forecasting and analysis of proposed changes in economic policy makes more demands on the model than does obtaining the best estimate of structural coefficients for some historical period. Not only is the true model unknown, but the definition of the correct model depends on the research problem.

Specification Issues

Model specification is concerned with how economic theory has been employed to transform the variables of a commodity market structure into a set of interrelated equations. Examples include the formulation of correct lag structures in perennial tree crop supply equations, the production response of farmers to risk, or the measurement of synthetic substitution effects. Model estimation requires estimating the parameters of the embodied regression equations with techniques that assure their unbiasedness, efficiency and sufficiency.

Important components of economic model building are tests for specification errors. Many models which appear to be estimated satisfactorily in terms 'sign' and 'significance' have performed poorly and have little to do with reality. Several authors have shown that the reason was partly due to little effort on the part of the researchers to validate their model (see, for example, Judge *et al.,* 1985 and Pagan 1984). As a consequence, recent years have witnessed a remarkable growth of interest in testing of econometric models. The idea that a model must be tested before it can be taken for further analysis has become widely accepted.

Several estimation problems are expected to occur when using Ordinary Least Squares (OLS) on the specified model. Applying OLS to a simultaneous setting almost certainly will produce bias estimates. If the estimates are biased, doubts will arise as to the usefulness of the model for policy analysis (or for any purpose the model was constructed). Limited or full information estimators which take into account the simultaneous nature may be required, but the final choice will depend on the results obtained from the model diagnostic tests.

In addition to the specification issues discussed above, the efficiency of the estimators can be further improved by imposing restrictions on the estimated equation as suggested by the duality theory. Previous authors have noted that ignoring the homogeneity and symmetry conditions from producer and consumer theory can lead to less efficient estimators. To fulfil these requirements, a system approach estimator may be called for.

Endogeneity and Exogeneity of Variables

As already noted, early applications in empirical econometrics assumed that variables could be correctly classified as endogenous and exogenous. Subsequent research indicates that such classification is not easy or obvious. If the research problem involves inference about structural parameters, then the explanatory variables need to be only weakly exogenous, i.e., predetermined. For forecasting, the variables must be strongly exogenous, and for analyzing future policy changes, the variables must be super exogenous. Statistical tests exist for various types of exogeneity, but they are not commonly used in agricultural economics.

The alternative notions of exogeneity in the literature suggest that the researcher needs to specify, at least implicitly, models of the exogenous variables. For example, to be weakly exogenous, a variable must be generated so that its contemporaneous covariance with the error term of the structural equation is zero.

Two inter-related, difficult problems are constancy of the structure over the sample period and correctness of the model specification (Alston and Chalfant, 1991). A correct model is understood to be one that includes all relevant variables (those with non-zero parameters), that has a correct functional form, and that excludes irrelevant variables. The typical model specification also assumes that the parameters of interest are constants over the sample period used for estimation. One can test for parameter constancy, but such tests are conditional on the correctness of the remaining model specifications. Or, one can test the correctness of selected model specifications assuming the parameters are constant over the sample period.

Specification of relevant variables includes how to model possible distributed lag effects. For time series data, lagged effects are likely to be important, but there are few definitive guides for modelling the length and form of the lag structure. If the analyst fits a relatively comprehensive, unrestricted model, the estimates are likely to have small bias, but large variances. If the analyst fits a relatively restricted model (by excluding variables, by restricting the form of the lag, etc.), bias is increased while the variance of the coefficients is reduced. The trade-offs in a mean squared error sense are difficult to evaluate.

Data Issues

Errors in variables are a potentially serious problem in empirical econometrics. Errors may be made in recording, compiling, and manipulating data, but care in data handling can minimize this problem. A more difficult issue is that observed variables are not good measures of the underlying economic concept. For example, expected output of an agricultural commodity is a function of prices expected to prevail at harvest-time, but how do farmers form expectations? Empirical models have used notions of naive expectations, adaptive expectations, quasi-rational expectations, and rational expectations. In empirical analyses, rational expectations must be specifically defined in terms of the model decision-makers are assumed to use in forming expectations. The limited evidence available suggests that empirical results are sensitive to the definitions of expectations.

Researchers must understand how the data series are constructed, so that they may be used appropriately in their research. Defining the data generating process for variables is not only a theoretical, but also an empirical issue. An important pre-condition for developing proxy variables for unobservable concepts is to understand the precise definition of the observed variables. Regrettably, some analysts are not careful, and therefore do not understand how data series are constructed.

For instance, domestic palm oil utilization in Malaysia is derived from balance sheets, using estimates of beginning inventories, production, exports, and ending inventories. Since the utilization is measured as a residual in this computation, it necessarily includes the aggregation errors contained in the various components of the balance sheet. Thus, measured palm oil utilization may be seriously in error relative to actual utilization, and if utilization is treated as a right-hand side explanatory variable in an inverse demand function, a serious errors-in-variable problem exists. This example suggests that understanding the specific definition of data series is important.

Observational data from government sources are often subject to revision. The researcher needs to assure that the data are internally consistent over the length of the sample period being used in the analysis. Also, the data should be carefully documented, so that subsequently an analyst could confirm the research. Perhaps the biggest problem in attempting to confirm the results of earlier published research is the inability to duplicate the data set used in the analysis. Many revisions can be viewed as reducing errors in variables. If, for example, an input into the balance sheet used to estimate feed consumption is changed, then presumably the new estimate of consumption is more nearly like actual consumption.

Analyses of time series are often plagued by collinearity of the variables. We should not be surprised that, say, the prices of substitutes are correlated or that some consumption series have common seasonal components. In my view, collinearity is one of the most misunderstood and difficult problems in empirical econometrics. Data for a particular set of variables have a given level of independent variability. This cannot be changed by transformations. Of course, transformations can change the correlation among regressors; the ultimate transformation is to orthogonalize the variables. But, the inherent independent information content of the sample is unchanged. Collinearity is analogous to having a small sample. A lack of an informative sample is regrettable, but cannot be changed.

Thus, solutions to collinearity must involve additional information: either additions to the sample or the use of non-sample information, which may take the form of restrictions on the model. The non-sample information may be in a classical or Bayesian framework. If restrictions on the model are used as a solution to collinearity, then the trade-off, discussed earlier, arises; namely, restrictions can reduce the variance of the coefficients, but likely at the cost of increasing the bias. Whether or not the restricted estimator is better in a mean squared error sense is difficult to tell. Clearly, there are no easy solutions to collinearity.

Another question is, are time-series variables stationary? Can we assume that the mean, variance, and auto-covariances (for fixed time lags) are constants? The usual large sample theory used to appraise least squares and instrumental variable estimators assumes that the variables are stationary, but some may not be. Numerous tests for stationary exist. A common set-up is to test the null that the variable is once-integrated, i.e., has a unit root (Dickey and Fuller, 1979). The usual tests have low power when the root is near one, but is not in fact one. Thus, the null hypothesis cannot be rejected unless strong evidence exists against it. Consequently, much uncertainty attaches to whether the time series commonly used in agricultural economics are stationary or not.

Variability and Fluctuations

There is a possibility that commodity market quantities and prices are often random. This introduces a large amount of risk and uncertainty into the process of commodity market modelling and forecasting. Of course randomness is implied generally and the nature of the price fluctuations varies as we observe them and their likely causes in the long, medium and short-term.

In the long-term, commodity markets are subject to shocks or changes in trend that range from natural catastrophes and political interventions to structural market changes. These shocks tend to be irregular in nature and cause abrupt shifts in prices usually to higher but sometimes to lower levels. Examples include the impacts of the haze in 1998 and the petroleum price increases. Sometimes the return of a market to normality is quick; at times the shocks persist; and at other times price changes reoccur, resulting in a series of consecutive turning points. Methods recently developed which help to analysed such trend changes appear in Badillo *et al.* (1999), Perron (1989), and Zivot and Andrews (1992).

In the medium term, factors that shock commodity markets can also be of a political or cataclysmic nature, but they tend to be more related to national economic conditions or to market forces themselves. Fluctuations in market forces tend to be observed in the demand and supply conditions and underlying market equilibrium. Fluctuations in national economic conditions, commonly observed in the form of business cycles, can cause changes in industrial production and hence in interest rates and ultimately commodity investments. Variations in weather conditions induce changes in agricultural supply and hence in product prices.

In the short term, market shocks come primarily from financial factors, particularly those related to speculation and hedging on commodity futures, Options and other derivative markets. The resulting price behaviour has been termed random, because it reflects the flow of randomly appearing information. In fact the price behaviour can be identified more specifically as being stochastic or following a nonlinear dynamic or stochastic process (e.g., autoregressive conditional heteroscedastic), or even a chaotic process. It can also be related more specifically to financial shocks such as in interest rates or exchange rates.

The described price fluctuations, which vary frequently and extensively, have made market modelling and forecasting an extremely difficult task. Linear and nonlinear time series methods which have been applied to stock prices and financial markets have been employed in commodity price analysis. Business cycle, econometric and time series methods that have performed effectively in macroeconometric forecasting have also been applied in commodity market forecasting.

Validation

Given a fully specified model, one of the most difficult issues is the answer to the question: Well, now that the model is complete, do we have any confidence in the answers it gives? Validation or verification of these models has been examined by several researchers. The basic validation tests which have been used involve: (a) how well the model solution, when specified with base period data, corresponds to the real situation in that base period; (b) whether the model feasibly can produce the base period demand quantity; (c) how well the model replicates the base period quantity (a test of whether price equals marginal cost); and (d) how well the model replicates base period quantities with prices fixed at base period. The validation tests which have been used generally relate to aggregate results. Regional production activities have not been validated systematically in the literature found by the authors. This is most likely because results from an aggregate model generally do not compare well to disaggregate regional production patterns.

Model validation requires that certain tests be performed with a model so that model users can have confidence in the ability of the model to perform reasonably well. The validation process normally embodies a series of tests, most of which are statistical in nature. For example, one can test the significance of model parameters, the accuracy between actual or predicted values of particular variables, or the ability of a model to predict turning-points correctly. In the case of simulation analysis, the accuracy of the behavioural response is often evaluated in terms of the realism of this response, when subjected to sensitivity or scenario analysis.

A model which does not pass validation would most likely leave the researcher in a difficult position. These models are conditional normative by nature and are therefore frequently valid by assumption. Tests involving validation have been attempted but when a model is "invalid," the model is usually examined carefully in terms of adequacy of coefficients and/or structure. Usually changes are then made and the model is re-examined for validation.

Furthermore, validation of the aggregate results does not totally validate a model. One still must be concerned with the adequacy of the supply and demand curves. Given an equilibrium solution to a problem, the slopes of the curves may be varied quite widely (providing the curve continues to pass through the equilibrium points) and the same equilibrium produced. The supply and demand curves are generally implicitly assumed to be valid by construct or valid through the process of their generation (i.e., econometric estimation).

Obstacles to Use

The major difficulty with econometric modelling is that its data requirements are extensive. Time, manpower, and financial resources required to construct a detailed model can be overwhelming.

A subtle weakness of this type of model revolves around the institutional question of who will use it. Beyond research use, then, there is the question of who will use such a model for policy. This may be a major stumbling block to implementation.

Impacts on Econometrics

The realization of how fragile empirical results can be had a major impact on econometric methods and methodology. First, it stimulated developments in other topics than estimation of structural models. The most notable is the vast expansion of the literature on time-series econometrics. This literature includes developments in specification, estimation and hypothesis testing for autoregressive moving average (ARMA) equations, vector autoregressions (VAR), the "state-space representation" of a dynamic system and Kalman filters, models of heteroscedasticity, particularly autoregressive conditional heteroscedasticity (ARCH) and its extensions, and models of univariate and multivariate time series with unit roots and of variables that are possibly cointegrated (Box and Jenkins, 1976).

Vector autoregression models were seen as an alternative to structural models. VARs have been used for forecasting and to some extent for policy analyses. Granger's causality test can be seen as a two variable VAR. Hence, VAR models can be used to test theories which suggest, say, that one variable in the system should fail to Granger-cause another. Theory may also suggest hypotheses about the time-series properties of a variable, or alternatively theorists may seek to explain empirical results obtained from VARs.

While econometricians have tended to divide into time-series and structural camps, developments in the time-series literature complement structural modelling. As Mad Nasir (1990) found out, time-series models are an alternative approach to some problems, such as forecasting. In addition, the literature on integrated and cointegrated time series and on conditional heteroscedasticity has helped improve structural models. Error correction models, for example, are potentially important specifications for dynamic structural equations.

A second methodological approach to structural modelling is called "general to specific modelling". Hendry (1995) and his colleagues (e.g., Davidson, *et al.,* 1978) are strong proponents of this approach, which is undertaken in a classical statistical framework. Here, the researcher starts with a general autoregressive distributed lag (ADL) specification that (hopefully) contains the simpler, but correct model of the phenomenon being analyzed. Consequently, one can conduct a sequence of tests of hypotheses nested within the general model in order to obtain the "final", simpler specification. A clear example is to start with a specification of lag length of "m" which is larger than the logical lag length "n," and then test down to find "n." By having a logical sequence of tests, it is possible to control the level of type I error in the final test. The ADL specification also helps deal with potential non-stationary variables that may be cointegrated.

In this approach, the "final" model is subjected to a series of tests of model adequacy, which are intended to act as quality control devices. The proposed tests are far more comprehensive than the usual examination of Durbin-Watson statistics, **t**-ratios, and coefficient signs that were the historical practice in agricultural economics.

The third major impact arising from the poor performance of structural econometric models is on econometric methods, especially the development of a large number of statistical tests of model misspecification (e.g., Godfrey, 1988; MacKinnon, 1992). This literature includes tests for omitted variables and incorrect functional forms, tests for autocorrelation, heteroscedasticity and non-normality of the errors, and tests for the constancy of regression parameters. There is also a large literature, already mentioned, on the exogeneity and stationarity of variables. In addition, methods exist to find outliers and observations with large influence on the results. Tests have been developed in the context of linear regression models, simultaneous equations models, and qualitative and limited dependent variable models.

The proliferation of tests relates, in part, to the large number of different data generating processes (models) to which the tests might be applied. Theoretical econometricians try to determine the statistical size and power of tests under varying circumstances. Our understanding of preferred tests evolves slowly however, and in empirical applications, the tests used are influenced by their convenience. It has been long known, for example, that the Durbin-Watson test for first-order autocorrelation is seriously biased when the model contains lagged endogenous variables. But, this test statistic continues to be reported simply because it is routinely computed by econometrics software packages.

Typically, the null hypothesis is that a particular specification is correct. If the null is rejected, the interpretation of the alternative may be ambiguous. For example, if the null hypothesis that the errors have zero first-order autocorrelation is rejected, it does not necessarily follow that the true errors have first-order autocorrelation. The rejection may instead be a sign of omitted variables or perhaps of higher-order autocorrelation. In general, rejection of a null tells the researcher that something is wrong, but usually not what is wrong. Nonetheless, the development of a wide variety of tests of model adequacy represents an important advance in evaluation of empirical results.

Finding that variables are not stationary, that models are inadequate, and so on has influenced the development of new models and estimators. A notable example is the literature on cointegration and error correction models. It is quite plausible that two (non-stationary) variables have a stable long-run relationship, but that short-run departures from the long-run equilibrium exist and that this behaviour needs to be captured by the model specification (by an error correction mechanism). Although the error correction model is just one particular specification, it encompasses a number of commonly used models in the literature, such as partial adjustment and finite distributed lag models (Hendry, 1995).

Given the diversity of plausible models, the literature on alternative estimators continues to grow as well. Naturally, this literature attempts to find the preferred estimator for each of the alternative models. If the error term is heteroscedastic but the researcher is uncertain about the form of the heteroscedasticity, what is the preferred estimator? If one observation seems to have "too large" an influence, how should it be trimmed? If we have errors in variables and potentially "weak instruments," what estimator should be used?

WHERE DO WE GO FROM HERE?

In the light of the reality of issues, it is possible to make some remarks on the direction of the econometric modelling of agricultural commodities as follows:

Data Requirements and Evaluation

The quality of data remains an important constraint on obtaining high quality empirical results. We must support adequate funding for the data generating agencies, and we need to seek new sources of useful data. Given the potential limitations of the available data, it is not always possible to estimate the desired structural parameters. The data sometimes will be inadequate to answer to the question asked.

The analyst must ascertain whether the observational data available for analysis are adequate for answering the research question. As already discussed, the data may be inadequate in several senses. The observed variables may not be a good measure of the underlying economic concept, and/or no data exist for the concept. Then, one must decide how to define proxy variables or to determine the consequences of omitted relevant variables. If the resulting estimates of the key parameter to answer the research question are fragile because of such problems, the conclusion may have to be that a precise answer is not possible.

Given a specific research problem and relevant data, the researcher needs to adopt a logical philosophy of modelling and of model evaluation. This starts with a careful study of the literature. What alternative, plausible theories exist in the literature, and how does the proposed model relate to this literature? Are alternative hypotheses nested (or not nested) within the proposed model? In some cases, it may be important to confirm selected results in the literature. Can they be duplicated? If so, how sensitive are these results to changes in the sample? Having started with a comprehensive specification, is a logical process of model simplification and evaluation followed? Once a tentative model has been obtained, can it pass a battery of tests of model adequacy? If the model is claimed to be better than alternatives in the literature, can this be demonstrated?

A complete evaluation would include using old data sets from previous research, current data, and ultimately new data. The best test of a model is its performance with new data. Thus, model evaluation should include replications, i.e., refitting the model to new data. To make research more cumulative, it is also important to compare alternative models using new data. Of course, if the data are observational time series, one must wait for time to pass for such analyses to occur. But, it would be possible to develop a program of research that went back into the literature to see how existing models perform with new data. At present, it is uncommon to try to duplicate published results and then use new data as a type of replication.

Graduate Level Teaching

The way graduate-level courses in econometrics are taught contributes to how empirical research is done. As noted above, the traditional approach to econometrics was to expect theory and logic to help specify the correct model; then the econometrician is just concerned with the questions of estimation and hypothesis testing. Also, it is natural to want students to have a strong foundation in statistics. Thus, textbooks and courses start with a heavy emphasis on the classical linear regression model, and of course if the data were actually generated in this way, the ordinary least squares estimator is the best unbiased estimator. This is often followed by a discussion of the generalized model in which the true error terms are assumed to be autocorrelated and/or heteroscedastic. If the true variance-covariance matrix is known, then generalized least squares is the best unbiased estimator.

While these topics are necessary background, they emphasize models that are usually unrealistic in economics. Students are perhaps led to false perceptions about the ease of building correct models or about the likelihood that estimators are unbiased. Models are far from perfect. Regressors are mostly stochastic, not non-stochastic. For time-series data, dynamic models with lagged endogenous variables are likely to be important. The true auto correlation coefficient is unknown, and indeed the most likely reason for autocorrelated residuals is model misspecification, not autocorrelation in the true errors. And so on.

Graduate students must be exposed to the problems associated with model uncertainty and with stochastic regressors. This in turn requires discussion of evaluation of data and models. Courses also need to deal with econometric methodology, such as general to specific modelling. In addition, practical topics, like use of models for forecasting and policy analysis, should be addressed in courses.

Additive Research

More attention should be given to the development of additive research in commodity and sector models and to the development of a broader framework for models of consumer demand, marketing margins, the processing sector, farm supply, and integration of these results into macro-models of the economy of the input-output variety. The trade sector becomes of prime importance in any such modelling. Similarly, the impact of changing input prices, such as energy, becomes more evident in such a framework.

Continued work is needed on means of incorporating the effects of policy changes, input costs, and technological developments on the supply side, and new products and changing tastes on the demand side. The need, however, for better data, especially as market structures affect availability of published series, is an obvious need. Given the empirical evidence presented by many agricultural economists, the implications of heterogeneity, dynamics and risk aversion should be given more weight in constructing commodity models of agriculture.

Frontiers of Needed Research

Among the more difficult challenges in commodity modelling is the considerable uncertainty which pervades the markets: speculative runs, exogenous shocks, political interventions, and structural changes. This uncertainty is also related to endogenous instability such as that caused by price inelasticities, excessive market speculation, and links to business cycles. Also important are supply-side changes such as those due to biotechnology or genetic adjustments. Influences on the demand side include the competitive development of synthetic and engineered materials. On a global scale, market destabilizing factors range from multinational market power and government controls to international economic and financial transmission and feedback effects.

A second important domain of research concerns how commodity market and price cycles are interrelated with national and international business cycles. The important economic and econometric results achieved by macroeconomists dealing with business cycle analysis should be applied and advanced in the case of commodity markets. Issues of how inflationary adjustments, monetary and exchange rate policies in the developed and developing economies are linked to commodity market fluctuations should be more carefully explored, including simultaneous inter reactions. Longer term analysis should be performed relative to periodic waves, trend-breaks, and regime-switching. Shorter term analysis should be conducted relative to the impacts of financial market shocks, economic uncertainty, and geopolitical disruptions. Researchers need more stock-flow knowledge of longer term investment and capacity adjustment cycles and of shorter term inventory and stocking cycles.

Many commodity price decisions are made when outcomes are uncertain. This uncertainty evolves from the market structure of the industry, the international instability of commodity markets, environmental problems, changes in technology and a host of other factors. Uncertainty has only recently been recognized as a feature in policy analysis and a complexity for commodity policy modelling. Important advances that deserve attention in policy analysis and modelling recognize choice under uncertainty.

The theory underlying a commodity price model will suggest the functional form for the structural equations. The typical relationships are estimated either in linear form or in a form that is linear in the parameters, for example, log-linear or some other transformation. While these forms generally conform to a theoretically formulated model, the functional form only broadly approximates the theoretical specification. This reflects the difficulty and cost of non-linear estimates when short sample periods are involved. While simplified functional forms, even linear approximations, may be suitable for many simulations covering a “normal” period, the difficulty is that the abnormal or extreme periods are precisely the points when the non-linearities of the model should become effective.

There is also the need to untangle more carefully the nature of commodity market structures and the role played therein by different forms of market interventions such as regulated prices, subsidies, taxes and trade controls. The potential of multidisciplinary analysis in this area might be limited, unless the disciplines of quantitative political analysis and of industrial organization advance in this direction.

A lesser amount of work has taken place regarding the role of market interventions and disruptions. Commodity models are thus likely to improve in the direction of offering a more realistic picture of these two related aspects of market structure. Another domain of research deals with developing country linkages. Still with us are problems of commodity export quantity and revenue stabilization stemming from international commodity price instability. Some research has commenced as to how to deal better with commodity price derivatives and financial instruments in the form of commodity risk management. Better understanding is needed of commodity investment formation, supply control and disruption, and the impact of import fluctuations on developed economy markets.

A most important research frontier concerns the behaviour of the core of the commodity market mechanism, i.e. the recursive and simultaneous adjustments of commodity markets. Important market variables in this respect besides prices are production, consumption, inventories, imports and exports.

The shocks that markets receive include not only business cycles on the demand side and climate cycles on the supply side, but also a variety of random shocks. This would suggest new investigations of models that are dynamic, nonlinear, and stochastic in nature. The structure of such models should include imperfect competition, government regulation, and special characteristics. The core of such models should reflect cyclical and disequilibrium adjustments, such as those occurring when demand does not equal supply and imports exceed exports. Model applications should be improved in the direction of employing newer approaches to market and policy simulation, and model forecasting should embody new probabilistic approaches for evaluating risk impacts.

CONCLUSION

After three years of modelling works, the author obtained his PhD, but there was a conflict in his mind as to whether econometric modelling is an art or a science since there were a lot of interactions between him, as a modeller, and the models that he tried to build. As a modeller, the author had to be creative in designing the structure of a commodity model, and yet he had to adhere to the economic theory, and after estimation, the model has to conform to *a priori* expectations of economic theory. After more than twenty years of modelling the Malaysian agricultural commodities, he realized that the process of model building is, first, a science, then an art, implying that it is both science and art.

Although commodity models have limitations, since models represent an abstraction of a rather complex real world, and models contain elements of both science and art, the contribution of econometric models to quantitative agricultural policy analyses and forecasting has been significant. If used properly, econometric commodity models can greatly enhance the quality of market forecasts, and provide valuable insight into the behaviour of commodity markets as well as the effectiveness of various economic policy measures. As with any other tool, it is important to be aware of its capabilities and limitations. Nevertheless, on the basis of the results obtained in the last few years, new demands for research have emerged that, if met, could lead to considerable improvements in the quality of this class of models; in terms of their capacity to represent the reality of agricultural sector, of the quality and scope of the results obtained, and of their statistical reliability.

In conclusion, it is evident that although the econometrician faces severe tests, the non-quantitative economist is apt to be in worse shape!

REFERENCES

Ahmad Fauzi Puasa, Mohd. Shahwahid Othman, Mad Nasir Shamsudin and Zakariah Abdul Rashid (2005) "The Welfare Economic Impacts and Implications on Sawn timber Export Levy Liberalization on the Peninsular Malaysia", *Malaysian Journal of Agricultural Economics,* 18(1): 1-15.

Ahmad Shuib, Khalid A. Rahim and Mad Nasir Shamsudin (1995) "International Commodity-related Environment Agreement (ICREA) and Sustainable Cocoa Production", *Options,* 10(2): 18-19.

Alston, J. M., and J. C. Chalfant (1991) "Can We Take the Con Out of Meat Demand Studies?", *Western Journal of Agricultural Economics*, 16: 36-45.

Amna Awad, Fatimah Mohd. Arshad, Mad Nasir Shamsudin and Zulkornanain Yusof (2005) "The Palm Oil Import Demand in the Middle and North African (MENA) countries", *Malaysian Journal of Agricultural Economics,* 18(1): 30-53.

Badillo, D., W.C. Labys and W.U. Yangru (1999) "Identifying Trends and Breaks in Commodity Prices", *European Journal of Finance*, 5: 315-330.

Box, E. P., and M. Jenkins (1976) *Time Series Analysis: Forecasting and Control,* revised edition, New York: Holden-Day, Inc.

Dickey, D. A., and W. A. Fuller (1979) "Distribution of the Estimators for Autoregressive Time Series with a Unit Root", *Journal of American Stat. Assoc.*, 74: 427-431.

Davidson, J. E. H., D. F. Hendry and S. Yeo (1978) "Econometric Modelling of Aggregate Time-Series Relationship between Consumers' Expenditures and Income in the United Kingdom", *Economic Journal,* 88: 661-692.

Fatimah Mohd. Arshad, Mad Nasir Shamsudin and Mohd. Shahwahid Hj. Othman (1993) *Malaysian Agricultural Commodity Forecasting and Policy Modelling*, Centre for Agricultural Policy Studies, Universiti Pertanian Malaysia.

Godfrey. L. G. (1988) *Misspecification Tests in Econometrics,* Cambridge: Cambridge Univ. Press.

Judge, G.G., R.C. Hill, H. Lutkepohl and T. Lee (1985) *The Theory and Practice of Econometrics,* 2nd Edition, New York: John Wiley and Sons.

Hendry, D.F. (1995) *Dynamic Econometrics*, New York: Oxford University Press.

MacKinnon, J. G. (1992) "Model Specification Tests and Artificial Regressions", *Journal of Economic Lit.*, 30: 102-146.

Mad Nasir Shamsudin (1985) *An Econometric Analysis of the U.S. Red Meat Industry with Emphasis on Intra-Industry Competition*, Unpublished PhD Thesis, Department of Agricultural Economics, Mississippi State University, USA.

Mad Nasir Shamsudin, Zainal Abidin Mohamed and Fatimah Mohd. Arshad (1988) "Selected Factors Affecting Palm Oil Prices", *Malaysian Journal of Agricultural Economics*, 5(1): 20-29.

Mad Nasir Shamsudin and Fatimah Mohd. Arshad (1990) "Composite Models for Short-term Forecasting for Natural Rubber Prices", *Pertanika,* 13(2): 283-288.

Mad Nasir Shamsudin (1991) "A Short Note on Forecasting Natural Rubber Prices Using a MARMA Model", *Malaysian Journal of Agricultural Economics,* 8(1): 63-73.

Mad Nasir Shamsudin, Mat Lani Rosdi and Chew Tek Ann (1992) "An Econometric Analysis of Cocoa Prices: A Structural Approach", *Jurnal Ekonomi Malaysia,* 25(2): 3-17.

Mad Nasir Shamsudin (1993) "The Effect of Import Liberalization of Cocoa Beans on Malaysian Cocoa Industry", *Borneo Review*, 4(2): 97-112.

Mad Nasir Shamsudin and Fatimah Mohd. Arshad (1993a) "Malaysian Palm Oil Market Model", In Fatimah M.A. *et al.* (ed.), *Malaysian Agricultural Commodity Forecasting and Policy Modelling,* Centre for Agricultural Policy Studies, Universiti Pertanian Malaysia.

Mad Nasir Shamsudin and Fatimah Mohd. Arshad (1993b) "Forecasting of Crude Palm Oil and Rubber Prices: Comparative Techniques", In Fatimah M.A. *et al.* (ed.) *Malaysian Agricultural Commodity Forecasting and Policy Modelling,* Centre for Agricultural Policy Studies, Universiti Pertanian Malaysia.

Mad Nasir Shamsudin and Fatimah Mohd. Arshad (1993c) "Short Term Forecasting of Crude Palm Oil Prices", *Proceedings of the 1992 PORIM International Palm Oil Conference,* Palm Oil Research Institute of Malaysia.

Mad Nasir Shamsudin and Zainal Abidin Mohamed (1993) "Analysis and Projections of Palm Oil Supply: A Vintage Approach", In Fatimah M.A. *et al.* (ed.) *Malaysian Agricultural Commodity Forecasting and Policy Modelling,* Centre for Agricultural Policy Studies, Universiti Pertanian Malaysia.

Mad Nasir Shamsudin, Mat Lani Rusdi and Chew Tek Ann (1993d) "A Market Model for Cocoa", In Fatimah M.A. *et al.* (ed.) *Malaysian Agricultural Commodity Forecasting and Policy Modelling*, Centre for Agricultural Policy Studies, Universiti Pertanian Malaysia.

Mad Nasir Shamsudin, Ahmad Zubaidi Baharomshah, Mohd. Shahwahid Othman and Fatimah Mohd. Arshad (1993e) "A Multi-Commodity Model for the Agricultural Sector", In Fatimah M.A. *et al.* (ed.) *Malaysian Agricultural Commodity Forecasting and Policy Modelling,* Centre for Agricultural Policy Studies, Universiti Pertanian Malaysia.

Mad Nasir Shamsudin, A. Webb and K. Hjort (1994) *Agricultural Sector Planning and Policy Analysis,* Consultancy Project Commissioned by Asian Development Bank and Economic Planning Unit, Prime Minister Department.

Mad Nasir Shamsudin and Mohd. Shahwahid Haji Othman (1994) "Economic Impact of the Export Levy on Sawn timber in Peninsular Malaysia", In Mohd. Shahwahid Haji Othman, *Opportunities and Constraints in Downstream Woodbased Industrialisation,* Centre for Agricultural Policy Studies, Universiti Pertanian Malaysia.

Mad Nasir Shamsudin and Fatimah Mohd. Arshad (1994) "Short Term Forecasting Model of Crude Palm Oil Prices", *The Planter*, 70(816): 129-137.

Mad Nasir Shamsudin, Fatimah Mohd. Arshad, Zainal Abidin Mohamed and Abdul Rahman Lubis (1994) "A Market Model for Malaysian Palm Oil Industry", *Malaysian Journal of Agricultural Economics,* 11(1): 81-102.

Mad Nasir Shamsudin, Fatimah Mohd. Arshad and Zainalabidin Mohamed (1995) "Short Term Price Outlook of Crude Palm Oil", *Proceedings of the 1993 PORIM International Palm Oil Conference,* Palm Oil Research Institute of Malaysia.

Mad Nasir Shamsudin and Mohd. Shahwahid Othman (1995) "A Market Model of Peninsular Malaysian Sawn timber Industry", *Pertanika Journal of Soc. Sci. and Hum.* 3(1): 47-53.

Mad Nasir Shamsudin and Jinap Selamat (1996) "Imposition of Export Levy on Cocoa Beans: Is It Timely?", *Options*, 11(1).

Mad Nasir Shamsudin (1997) "The Effect of Export Duty Reduction on Malaysian Palm Oil", *Journal of Agricultural Economics,* 61: 137-152.

Mad Nasir Shamsudin, Fatimah Mohd. Arshad and Fauziah Abu Hassan (1997) "The Effect of Export Duty Liberalization on the Malaysian Palm Oil Industry", *Malaysian Oil Science and Technology,* 6(2): 79-82.

Mad Nasir Shamsudin, A. J. Webb and K. Hjort (1997) *Development of Malaysia Agricultural Sector Analysis Model*, Proceeding of the Seventeenth Annual International Symposium on Forecasting, International Institute of Forecasters.

Mad Nasir Shamsudin (1998) "The Effect of Export Levy on Malaysian Cocoa Industry", *Pertanika Journal of Social Science and Humanities*, 6(1): 23-29.

Mad Nasir Shamsudin, A. J. Webb and K. Hjort (1998) "Development of Malaysian Agricultural Sector Analysis Model", *Journal of ISSAAS,* 4(2): 23-37.

Mad Nasir Shamsudin and Alan J. Webb (1998) "Food Outlook: Malaysia", *Pacific Food Outlook 1998-99, Pacific Economic Cooperation Council.* (*www.pecc.org/food)*

Mad Nasir Shamsudin and Tengku Mohd Ariff (2005) *The Impacts of AFTA and WTO Compliances on the Malaysian Rice Industry*, UPM Exhibition of Invention, Research and Innovation 2005.

Malaysia (2006) *Ninth Malaysia Plan 2006 – 2010,* Kuala Lumpur.

Ming Yu Cheng, Hui Boon Tan and Nasir Shamsudin (2001) "Domestic and International Transmission of Inflation: the Malaysian Experience", *The Asian Economic Review:* 43(1): 1-12.

Ministry of Agriculture (1998) *Third National Agricultural Policy 1998 – 2010,* Kuala Lumpur.

Mohammad Yusoff and Mad Nasir Shamsudin (1993) "Production and Trade Model of Malaysian Natural Rubber Industry", In Fatimah M.A. *et al.* (ed.) *Malaysian Agricultural Commodity Forecasting and Policy Modelling,* Centre for Agricultural Policy Studies, Universiti Pertanian Malaysia.

Mohd. Shahwahid Othman and Mad Nasir Shamsudin (1993) "Sawn timber Export Levy and Its Impact on the Timber Industry", *Malaysian Journal of Economic Studies,* Vol. XXX (2): 45-57.

Pagan, A.R. (1984) "Model Evaluation by Variable Addition", In Hendry D.F. and K.F. Wallis (ed.), *Econometric and Quantitative Economics,* Oxford, Basil Blackwell.

Perron, P. (1989) "The Great Crash, The Oil Shock and the Unit Root Hypothesis", *Econometrica,* 57:1361-1402.

Webb, A.J., Mad Nasir Shamsudin and K. Hjort (1997) *A Malaysian Agriculture Projections Model: A User-Friendly Framework for Policy Analysis,* Presented at the American Agricultural Economic Association Meeting, San Francisco, USA.

Ying-Nan Lin and Mad Nasir Shamsudin (1992) "The Dynamic Characteristics of Pork-Hog, Beef-Cattle and Corn Subsectors and the Competition between Hog-Pork and Beef-Cattle Industries in the United States", *Journal of Economics and Finance,* 16(1): 81-102.

Zivot, E. and D. Andrews (1992) "Further Evidence on the Great Crash, the Oil Price Shock, and the Unit Root Hypothesis", *Journal of Business and Economic Statistics,* 10: 271-287.

BIOGRAPHY

Professor Dr Mad Nasir Shamsudin, born in Muar, Johor in 1956, is professor of Agricultural and Resource Economics at the Faculty of Environmental Studies and Faculty of Agriculture, Universiti Putra Malaysia (UPM). He obtained a Diploma in Agriculture in 1978 from UPM. He then earned his BS degree in 1980 in Agricultural Economics from Louisiana State University, and his PhD in 1985, also in Agricultural Economics with minor in Statistics, from Mississippi State University. He performed exceptionally well as a student and he received an Award of Merit for being the Best Undergraduate Student (CGPA 3.84) in the College of Agriculture at Louisiana State University.

As an academic staff of UPM, he has been active in teaching, research, advisory services and administrative duties. He teaches at both undergraduate and graduate levels in his specialised area of Agricultural and Resource Economics, as well as in Microeconomics, Managerial Economics and International Trade. He has been an external examiner for PhD theses at Curtin University of Technology, Australia; Massey University, New Zealand; University of Rajshahi, Bangladesh; and local universities, such as Universiti Kebangsaan Malaysia and Universiti Sains Malaysia. He has also been appointed as an Expert Member of the Selection Committee for appointment of professor at Bangladesh Agricultural University, Mymensingh.

In the research arena, he has been awarded research grants from various local as well as international institutions. His capability and potential as a researcher in the area of agricultural and resource economics was recognised internationally, and he was awarded the Cochran Middle Income Countries Fellowship as a visiting agricultural economist at the Centre for Rural and Agricultural Development (CARD), Iowa State University, conducting research on Malaysian agricultural commodity modelling and forecasting. His research outputs are published in local and international journals; some prominent ones being the Journal of Economics and Finance, the Journal of Agricultural Economics, the American Journal of Alternative Agriculture, the Journal of Sustainable Agriculture, the Journal of International Food and Agribusiness Marketing, the Asian Economic Review and the Journal of International Society for Southeast Asian Agricultural Science. To date, he has authored and co-authored four books. His research outputs have made a significant contribution to the understanding and advancement of agricultural and resource economics.

In recognition of his expertise and research capabilities, he was appointed as a researcher and consultant to the Economic Planning Unit (EPU), Prime Minister's Department, under Asian Development Bank technical assistance for one year. He successfully developed a Malaysian agricultural commodity forecasting model during this period. This project also provided technical training to the EPU staff in order to improve policy analysis and long-term planning for the Malaysian agriculture sector. He is also involved in evaluating national research and was appointed as a member of the Socio-Economic Panel of IRPA. Currently, he is a member of the Fundamental Research Grant Evaluation Committee (FRGS).

In addition to research, Professor Nasir has also been involved in various consultancies at the national as well as international level. These include projects with the Ministry of Agriculture and Agro-based Industries, the Ministry of Plantation Industry and Commodities, the Ministry of Rural Development, the Asian Development Bank (ADB), the Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP) and the Asia-Pacific Economic Cooperation (APEC). Currently, he is a consultant to a study group comprising five member ASEAN economies on "Market Liberalization and its Relationship with Market Structure, Conduct and Performance of Selected Food Processing Industry in APEC Member Economies", funded by the APEC Secretariat.

His nation-wide reputation is also acclaimed when he was invited to be a member on various committees in several government agencies. He was appointed, among others, to the Technical Advisory Committee of the Malaysian Cocoa Board, the Board of the Malaysian Cocoa Board, the Consultative Panel on Agricultural Productivity of the National Productivity Corporation, and the Agriculture Consultation Working Group, Ministry of International Trade and Industry.

On the international front, he is a member of the Pacific Food System Outlook Forecasting Panel under the Pacific Economic Cooperation Council (PECC). This network comprises of forecasting experts in the agricultural sector from all the PECC countries.

In recognition of his academic and leadership capabilities, he was appointed as Head of the Agricultural Economics Department (August 1996 – December 1998), Head of the Agribusiness and Information Systems Department (January 1999 – December 2003), Deputy Dean, School of Graduate Studies (March – August 2004), and is currently Dean, Faculty of Environmental Studies since September 2004.

In addition to his academic duties and services to the government, Professor Nasir is actively involved in the professional development of agricultural and resource economics. He is current president of the Malaysian Agricultural Economics Association, and member of the International Agricultural Economics Association, the American Agricultural Economics Association, the Southern Agricultural Economics Association, the International Institute of Forecasters, and the International Association of Southeast Asian Agricultural Science.

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