ESTIMATION OF MEAT DEMAND SYSTEM IN MALAYSIA: MODEL SELECTION BETWEEN THE ROTTERDAM MODEL AND THE FDLAIDS MODEL

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by

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$u = v(q_1,\ldots q_n)$	Utility function of the quantities of goods consumed
$q_i = g_i(x, \boldsymbol{p})$	Marshallian or uncompensated demand function
$q_i = h_i(u, \boldsymbol{p})$	Hicksian or compensated demand function
$\boldsymbol{p}$	Vector of commodity prices
$\sum p_i q_i = x$	Budget constraint
q_i	Quantity of the i^{th} meat commodity
p_i	Price of the i^{th} meat commodity
$w_i = \frac{p_i q_i}{x}$	Expenditure/budget share of the i^{th} meat commodity
$\bar{w}_i$	Average budget share of the i^{th} commodity weighted between consecutive time periods t and $t-1$
Δ	Across periods first difference operator
log	Mathematical function used to estimate the logarithm of a number.
$q_{i,t}$	Quantity demanded of good i at time t
$p_{j,t}$	Nominal price of good j at time t
DQ	Real income term
X_t	Total expenditure on the n goods at time t,
a_i	Intercept parameter of the i^{th} meat commodity
γ_{ij}	Price parameters of the i^{th} meat commodity
β_i	Expenditure parameter of the i^{th} meat commodity
$\sum_{i=1}^{n} w_{i,t} \log p_{i,t}$	Stone price index
$\Delta w_{i,t}$	First differenced budget-share at time t.
$\varepsilon_{i,t}$	Residual of the i^{th} meat equation at time t

$a_{im} = a_{0i} + \sum_{k=1}^{K} \phi_{ik} Z_k$	The process of augmenting demographic variables to known demand systems, also called demographic translating.
Z_k	k^{th} demographic variable
$\phi_{i,k}$	Parameter estimate of the i^{th} meat commodity for demographic variable k
$\lambda y + (1-\lambda)z = f(x)$	Box-Cox transformation
ϕ	Coefficient of the Rotterdam model in the non-nested test
λ	Coefficient of the FDLAIDS model in the non-nested test
F_{RAO}	Rao's System-wise *F*-Statistics
m	Number of restrictions per equation
g	Number of equations in the unrestricted system
det	Determinant of a matrix
H_R	Restricted residual covariance
H_U	Unrestricted residual covariance
T	Total number of equations
$\hat{\varepsilon}_{it}$	Estimated residuals
$f_i(x_t, \Theta)$	Original regressors of the i^{th} equation
$\bar{\bar{w}}_i$	Across periods mean budget shares
η_i	Expenditure elasticity
e_{ij}^u	Uncompensated price elasticity
e_{ij}^c	Compensated price elasticity
y_t	Observed values of the left-hand sides of each demand equation in year t
$\hat{y}_t$	Predicted values of the left-hand sides of each demand equation in year t
$\hat{y}c$	Relative change of the predicted value of each demand equation
yc	Relative change of the actual value of each demand equation
U	Theil's Inequality coefficient

LIST OF ABBREVIATIONS

AIDS	Almost Ideal Demand System
BNM	Bank Negara Malaysia
CPI	Consumer Price Index
DVS	Division of Veterinary Services
IFPRI	International Food Policy Research Institute
IML	Integrated Matrix Language
ITSUR	Iterated Seemingly Unrelated Regression
FAMA	Federal Agricultural Marketing Authority
FDLAIDS	First Differenced Linear Approximate Almost Ideal Demand System
FAOSTAT	Food and Agriculture Organization Statistical Database
GLAIDS	Generalized Almost Ideal Demand System
LA/AIDS	Linear Approximate Almost Ideal Demand System
LES	Linear Expenditure System
RMSE	Root Mean Squared Error
MSE	Mean Squared Error
OLS	Ordinary Least Squares
SAS	Statistical Analysis System
SAS/ETS	Statistical Analysis System/Econometric Time Series Software
SUR	Seemingly Unrelated Regression
TVC-AIDS	Time-varying Coefficients of the Almost Ideal Demand System
UN	United Nations
UNSTAT	United Nations Statistical Database

LIST OF PUBLICATIONS & SEMINARS

1.1 Paraguas, M.S. and Anton, A.K. 2005. “Estimation of Meat Demand System in Malaysia: Model Selection Between the Rotterdam model and the AIDS.” *International Journal of Mathematical Sciences*. Vol 4 no: 2.

1.2 Paraguas, M.S. and Anton, A.K. 2005. “Analysis of Meat Demand in Malaysia: Model Choice Between Rotterdam and AIDS”. In *Proceeding of the 1st IMT-GT Regional Conference on Mathematics, Statistics and Their Applications (IRCMSA), II, 2005* (Mawengkang, H. Saib, S. and Sutarman, eds), pp. 236-245. 13-15 June 2005, Lake Toba, Indonesia.

1.3 Paraguas, M.S., Paragaus, F.J. and Anton, A.K. 2005. “Integrating Weather Data, Rice Eco-physiological Growth Process And Markov Chain to Forecast Rice Yields”, Proceeding of the *Ecological and Environmental Modelling 2004 (ECOMOD 2004),* Universiti Sains Malaysia, 13-15 September 2004 (forthcoming).

1.4 Ahmed, M. and Paraguas, M.S. 2005. “Structural Changes and the Impact of WTO on Fishery and Agricultural Trade”, *Co-author, Worldfish Center draft working paper.*

PENGANGGARAN BAGI SISTEM PERMINTAAN DAGING DI MALAYSIA: PEMILIHAN MODEL ANTARA MODEL ROTTERDAM DAN MODEL FDLAIDS

ABSTRAK

Data siri masa aggregat digunakan terhadap hasil daging yang berbeza seperti daging lembu, daging khinzir, daging kambing, dan daging ternakan ayam, untuk penganggaran dan menganalisa permintaan pasaran daging di Malaysia. Kajian ini bertujuan untuk memilih model permintaan yang paling sesuai diantara model Rotterdam dan model *First Differenced Linear Approximate Almost Ideal Demand System (*FDLAIDS) dengan menggunakan pendekatan 'tak bersarang'. Beberapa pembolehubah demografi juga telah dimasukkan ke dalam model permintaan untuk menentukan kesesuaian model dan mengenalpasti kesannya terhadap permintaan daging seterusnya menerangkan perubahan-perubahan dalam model tersebut.

Keputusan pemilihan model adalah tidak jelas. Kedua-dua model, model Rotterdam dan model FDLAIDS, dengan wujud atau tidaknya kesan demografi, adalah diterima sebagai model yang sesuai untuk data ini. Namun, kriteria diskriminasi seterusnya memperlihatkan model FDLAIDS didapati lebih sesuai mewakili permintaan daging untuk pasaran Malaysia berbanding model Rotterdam, tanpa mengira kewujudan kesan demografi didalam model. Selain itu, keanjaian model FDLAIDS didapati lebih dipercayai daripada model Rotterdam.

Peningkatan kadar penglibatan buruh wanita begitu juga kadar urbanisasi didapati mempunyai kesan signifikan ke atas corak penggunaan daging. Walaubagaimanapun, perubahan didalam nisbah ras yang berbeza iatu Melayu, Cina, dan India, dan perubahan nisbah populasi yang berumur tidak mempengaruhi corak permintaan daging.

ESTIMATION OF MEAT DEMAND SYSTEM IN MALAYSIA: MODEL SELECTION BETWEEN THE ROTTERDAM MODEL AND THE FDLAIDS MODEL

ABSTRACT

Aggregated time series data for differentiated meat products namely, beef, pork, poultry and mutton were used to estimate and analyze Malaysian market demand for meats. The study aimed to select the most appropriate demand model between the equally popular Rotterdam model and the First Differenced Linear Approximate Almost Ideal Demand System (FDLAIDS) model by using a non-nested approach. Also, several demographic variables are augmented to the demand models to determine their effect on the choice of the suitable model as well as to identify their impact on meat demand, and to model potential structural change.

Results of the model selection are ambiguous. Both Rotterdam and the FDLAIDS models with and without the presence of demographic effects are accepted as an appropriate model for this data. However, further discrimination criteria revealed that the FDLAIDS model with or without the presence of demographic effects represents more appropriately the Malaysian market demand for meat than the Rotterdam model. Also, the elasticities from the FDLAIDS were found to be more reliable than the Rotterdam model.

The increasing rates of female labour force participation as well as the rising rate of urbanization appear to have a significant impact on the observed meat consumption pattern. On the other hand, the changes in proportion of different racial population (i.e. Malay, Chinese and Indian) and the changes in proportion of the aging population have no effect on the demand pattern for meats.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The analysis of consumer demand is one of the oldest topics in applied econometrics (Theil 1978). Earlier studies use single equation techniques to estimate commodity demand by consumers. But in the last several decades, consumer demand analysis has moved toward system-wide approaches (Lee, Brown, and Seale 1994). System-wide approaches ensure that the demand system is consistent with consumer theory. On the other hand, single equation specifications are primarily concerned with estimating elasticities and paid little attention to consumer theory (Deaton and Muellbauer 1980b).

There are numerous algebraic specifications of demand systems; these are Linear Expenditure System (LES) developed by Stone (1954), the Translog model of Christensen, Jorgenson, and Lau (1975), the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980a), the Rotterdam model of Barten (1964) and Theil (1965), Generalized Almost Ideal Demand System (GAIDS) proposed by Bollino (1987) and many others. Generally, different demand systems have different implications (Lee, Brown, and Seale 1994). Thus, an important issue in empirical analysis is choosing the appropriate functional form which would provide the most meaningful and statistically adequate estimates. However, the usual approach of most researchers is to arbitrarily pick one model, but recent interest has focused on properly selecting the appropriate demand system.

This study looks at the appropriate demand function for meats in Malaysia. Aside from considering the appropriate functional form, the study focuses on whether several demographic variables have detectable effects on Malaysian meat demand.

Understanding meat demand and its characteristics is important in order to give a more accurate evaluation of the factors that govern consumers' behaviour for meat products. Meats are an important component of Malaysian diet. About 25% of total protein intake of Malaysians is estimated to be from meats (Mohamed and Abdullah 1987). With rapid population growth and improved per capita income as well as lifestyle changes resulting from urbanization, it is predicted that there will be further increases in demand for meat products in the country.

The overall level of self-sufficiency in livestock meat products is rather high. However, this is due to pork and poultry meats of which about 60% of production is exported to other countries including Singapore (Zainalabidin and Shamsudin 1990). Moreover, the self-sufficiency level for beef has been declining over the years. Efforts have been made to increase beef production; nevertheless the progress has been slow. Currently, Malaysia imports about 80% of its beef requirement from various countries to meet local beef demand, which amounts to RM300mil annually (The Star Online 2004). For mutton, though the consumption figure is small compared to beef, pork, and poultry, about 85%-90% of mutton has to be imported to meet local demand. In 2002, Malaysia imported approximately 13,217 metric tons of mutton, which is about 90% of the local requirement FAOSTAT (2005). Hence, knowing the demand for meat products is thus an important concern for policymakers due to its impact on self-sufficiency, changing food prices, and the nation's trade balance (Shamsudin and Jinap 2004).

1. 2 Statement of the Problem

From the time when Stone (1954) estimated the first complete demand system derived explicitly from consumer theory, the consumer demand literature has flourished with studies in which different models and estimation techniques of demand functions are applied. The two most widely adopted especially in food demand studies are the Rotterdam model introduced by Barten (1964) and Theil (1965), and the AIDS model of Deaton and Muellbauer (1980a). Both models are derived from consumer theory, and are used to impose or test behavioural restrictions that are deduced from that theory (Kastens and Brester 1996). However, neither economic theory nor statistical analysis provides clear *a priori* criteria for choosing between these two models (Lee, Brown, and Seale 1994). Thus, the choice between which models fits better for a particular data set is an empirical question.

In Malaysia, some studies have been conducted to analyze consumer demand for meat. Abdullah (1994) estimated both static and the dynamic AIDS in analyzing demand for fish and meat products in the country using time series data from 1960 to 1990. His result showed that the dynamic AIDS performed better than the static version. In an earlier study, Baharumshah (1993) used a linear approximate AIDS and tested the model for serial correlation. A recent study by Milad (2003) adopted the Rotterdam model using data from 1970-2000. An ex post analysis was done to validate the model. In these studies, only one functional form is used, so the choice of the model is made arbitrarily or the demand model is selected based on diagnostic tests. No study has been done to select the correct model by using a non-nested hypothesis test. Also, no study has been conducted to compare different model specifications that best fit the demand for meat in Malaysia.

Furthermore, the existing literature on the demand studies in Malaysia is typically modelled as a function of own-price, prices of competing meats, and other potential demand shifters, like, total meat expenditures. However, many meat demand studies in other countries like the U.S. (e.g., Eales and Unnevehr 1993; Moschini and Meilke 1989; McGuirk et al. 1995) have concluded that the impacts of competing meats prices specifically for beef consumption are not stable. This suggests meat consumption patterns are determined by other factors in addition to relative prices and total meat expenditures. Hence, undertaking a study to incorporate other demand shifters aside from the price-related determinants of market meat demand is important. These demand shifters could be utilized to model structural changes on Malaysian market meat demand.

1.3 Objective of the Study

The chief aim of this research is to select the appropriate demand model, which best estimates and explains the variation in the Malaysian demand for meats. In addition, the study aims:

1. To compare and analyze the two functional forms namely, First Differenced Linear Approximate Almost Ideal Demand System (FDLAIDS) and the Rotterdam model.
2. To test theoretical demand restrictions and apply system-wise diagnostics tests to support the selection of the best-fitted model.
3. To incorporate demographic variables that would allow the estimation and modelling of structural change in the Malaysian meat demand.
4. And to estimate the demand elasticities for each meat commodity with respect to its own-price, prices of other goods, total expenditures and other possible demand shifters.

1. 4 Hypotheses of the Study

For this study several hypotheses can be inferred:

1. First Differenced Linear Approximate Almost Ideal Demand System (FDLAIDS) model is hypothesized as the correct model for this data set.
2. Expenditure elasticities are expected to be positive, own-price elasticities negative, and Hicksian cross-price elasticities are expected to be positive, since meat products are generally considered to be normal goods and to substitute for each other.
3. The proportion of Malays in the population is assumed to significantly affect the demand for meat products in the country especially for beef and chicken.

1. 5 Significance of the Study

The results of the study would be significant to the policy makers and other interested parties in aiding them make strategic decisions about the Malaysian consumer's behaviour in the consumption of meat products. It would provide a picture on the demand for differentiated meat products in the country. It will be a very essential tool for policy planning on further livestock development as well as in the field of international trade. Specifically, in meeting the expected production and supporting the increasing demand for meat. Thus, research on the demand for goods or specifically for meat on a regular basis is necessary.

Also, result of this study will add to the precious little stock of literature on the complete meat demand system analysis of the country. Most significantly, the use of non-nested hypothesis test for model selection will contribute to the literature of consumer demand.

1.6 Limitation of the Study

Statistical data on the consumption pattern of animal products in this country are often incomplete as no adequate or regular surveys are conducted (Hashim, 1987). This is why most meat demand studies in Malaysia use annual time series data rather than monthly, quarterly data or even cross-sectional household level data. Results from annual time series data can be limiting but can still be important in analyzing market demand trends. However, monthly or quarterly data may provide more information (e.g. seasonality of demand) and would increase the sample observation. Moreover, utilizing sample observation from a cross-sectional household level data would be more informative due to the richness of demographic data often absent in time series (Heien and Wessels 1988).

Aside from data limitations, the present study is also constrained to the study of only four meat types namely beef, pork, poultry and mutton. Including fish or other food groups would make the analysis even more informative as these other food items have also significant impact on the demand and supply of food in the country.

1.7 Organization of the Study

The remainder of the study is organized as follows: Chapter 2 briefly describes the meat consumption patterns of Malaysians. It presents the increasing pattern of demand on meat products and the influence of rising income and racial composition on the consumption trends in the country.

Chapter 3 provides a comprehensive literature review about the empirical application and survey of demand studies focusing between the Rotterdam and the AIDS models. The development and empirical studies of non-nested model selection

approaches are also reviewed and discussed. In addition, limited numbers of empirical demand studies in Malaysia are discussed, concentrating on the demand specification used.

The next chapter, Chapter 4, presents the general research methodology of the study. First, the concepts of demand theory and demand analysis as well as elasticities are highlighted as part of the framework from which the theories are based. Secondly, the model specification of the Rotterdam and the AIDS models are presented. Also, the structural specifications of the models are also discussed by augmenting several demographic variables that are assumed to affect the demand for meats in Malaysia. Moreover, the presentation of the Rotterdam and the FDLAIDS models as non-nested models, and the appropriate model selection test methodologies are also discussed in this chapter. Lastly, the description of the data and estimation procedures are then presented.

Chapter 5 reports the results and summary of the major findings. It starts with the summary description of the variables used in the study. Then, model selection results between the two functional forms with and without the demographic variables are reported. Also, results of further tests via considering the various discrimination criteria to properly select the most appropriate model are also reported. In this section, the empirical results between the Rotterdam and FDLAIDS are compared and analyzed.

Chapter 6 discusses the summary and conclusion. Lastly, Chapter 7 provides the recommendations for future research.

CHAPTER 2

MEAT CONSUMPTION PATTERN IN MALAYSIA

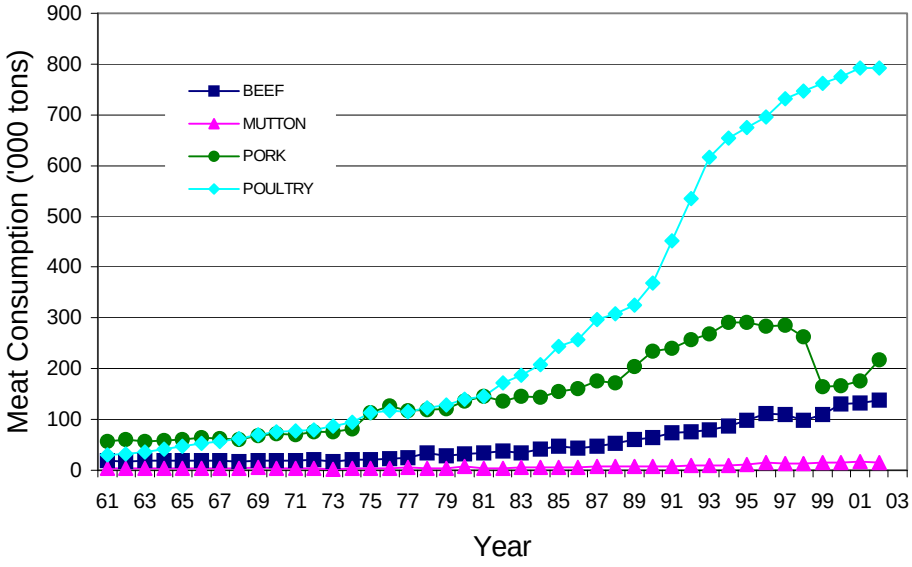
2.1 Consumption Trends

Over the last decades, Malaysia experienced rapid economic and population growths fuelling the massive increase in demand-driven consumption for food of animal origin. The trend in consumption over the last years showed that there have been steady increases in the demand for meats in Malaysia. As evident in Figure 2.1, the Malaysian consumption patterns for meat products have changed considerably over the last decades. The most striking feature is the steady increase in poultry consumption, which has more than tripled in the last 40 years. The rapid development of the Malaysian poultry industry can partly account for this trend (Zainalabidin, Shamsudin, and Ghaffar, no date). Other explanations suggest that changes in the structure of meat demand are result of changing consumer demographics (racial structure), changing food prices, and most of all, an evolution in consumers' taste and preferences.

Meat and poultry consumption is becoming more important in the Malaysian diet. Over the 1961-2002 periods, Malaysian meat consumption pattern has increased ten fold from 108,219 to 1,162,937 metric tons (Fig 2.1). The remarkable growth in consumption is attributed from poultry and pork. Pork consumption is higher than poultry in the 1961-1966 periods, but poultry gained momentum in the late 1960s. In 1970, 74,889 metric tons of poultry were consumed by the population and reached to 792,786 metric tons in 2002. Pork consumption increased from 56,416 metric tons in 1961 to 216,987 metric tons in 2002. Beef consumption is higher compared to mutton. Mutton shared the lowest

consumption figure but also increased steadily from 3,423 metric tons in 1961 to 15,251 metric tons in 2002.

Figure 2.1 Annual Meat Consumption in Malaysia, 1961-2002



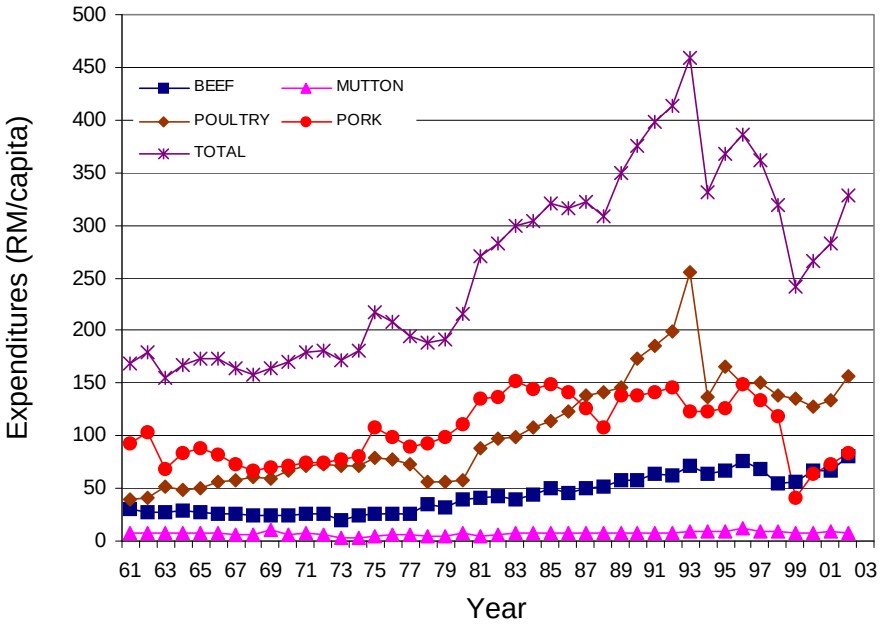
Source: FAO, 2004

2.2 Expenditure Trends

Expenditures provide information on how consumers are allocating their income among competing commodities. Figure 2.2 illustrates the trend in per capita meat expenditures over the whole sample period. Total inflation-adjusted meat expenditures increased from 1961-1975, fluctuated and reached its peak in year 1993, and then declined until 1999. The fluctuations in the meat expenditure were virtually attributable to the fluctuating expenditure on poultry and pork as mutton expenditure was nearly constant, and beef expenditure marginally increased. This indicates consumers allocated

substantial total ringgits to meat expenditures over time, primarily due to the higher but fluctuating expenditures on poultry and pork.

Figure 2.2 Annual Inflation-Adjusted (2000 Dollars) Per Capita Beef, Mutton, Pork, and Poultry Expenditures, 1961-2002

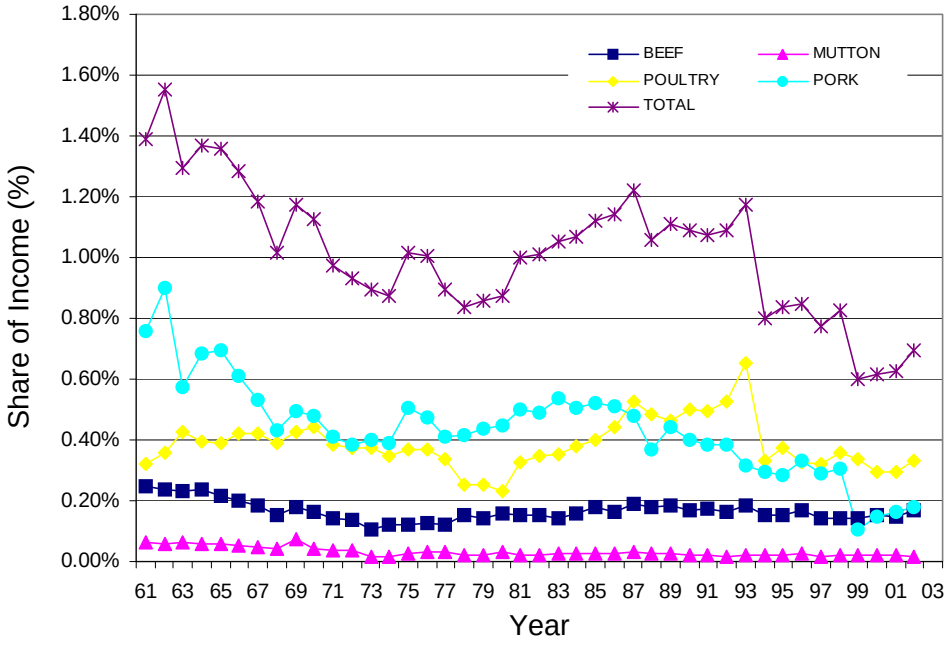


Source: FAO, 2004
DVS and FAMA various bulletins
Bank Negara Malaysia

How consumers have allocated per capita disposable income among competing meats is closely related to the expenditure share allocation (Schroeder, Marsh, and Mintert 2000). Figure 2.3, shows the shares of consumer income allotted among beef, mutton, pork and poultry from 1961-2002. In 1961, consumers allotted 1.0% of their disposable income on meat, with 0.18% going to beef, 0.04% to mutton, 0.54% to pork and 0.23% to poultry. By 1987, consumers had allotted 1.22% of their income to total meat, the share of pork decreased by 0.07%, poultry had the highest share with 0.52%,

while 0.03% was spent on mutton and around 0.19% to beef. After 1992, the total expenditure spent on meat declined. In 2002, consumers only spent 0.69% of their disposable income on total meat. Poultry shared the highest expenditure with 0.33%; followed by pork with 0.18%, beef with 0.17% and mutton 0.02%. The proportion of total expenditures on meat declined towards the last period, this indicates that family income of Malaysians have increased, revealing the affluence of majority of the Malaysians towards the end of the sample period.

Figure 2.3 Beef, Mutton, Pork, and Poultry Expenditures as a Percentage of Income, 1961-2002



Source: FAO, 2004
DVS and FAMA various bulletins
Bank Negara Malaysia

2.3 Racial Background and Consumption Behaviour

The meat consumption behaviour of Malaysians is also influenced by their race and ethnicity. Racial or cultural background of the population has a strong influence in the meat demand of the country. Pork is forbidden to Muslims of which majority are Malays, and beef is prohibited to Hindus of which majority are Indians (Zainalabidin and Shamsudin 1990). Among the meat commodities, only poultry meat is popularly consumed due to its pricing and religious acceptability. Unlike poultry meat, preference for mutton is lower among Malaysians although there is no social or religious prohibition attached to it (Zainalabidin and Shamsudin 1990).

Among the racial groups, the Malays and other Muslims form the highest consumers of beef and mutton. The Indians follow closely as a major consumer of mutton. While the remaining non-Malay/Muslim population, estimated to be about 50%, are the pork eaters. And from this portion of the population, the Chinese are the predominant consumers of pork (Hashim 1987).

CHAPTER 3

REVIEW OF LITERATURE

3.1 Introduction

This chapter provides a brief review of the relevant literature for understanding and analyzing the specific issues of interest related to the objectives of the present study. Various studies regarding consumer demand behaviour were conducted in many countries and had taken into consideration numerous techniques in estimating the demand functions of these goods. In agricultural economics literature, two demand systems have become popular: the AIDS and the Rotterdam model. The AIDS model introduced by Deaton and Muellbauer (1980a) has been widely adopted and now appears to be the most popular of all demand systems. Whereas, the Rotterdam model, first proposed by Barten (1964) and Theil (1965), is gaining acceptability and is predicted to be the main alternative to the AIDS model (Alston and Chalfant 1993).

3.2 The Almost Ideal Demand System (AIDS)

The AIDS model of Deaton and Muellbauer (1980a) is widely used in many countries and has been a prominent method of analyzing consumer demand pattern. Deaton and Muellbauer (1980a) first applied the model to estimate demand on eight non-durable goods, namely, food, clothing, housing services, fuel, drink and tobacco, transport and communication services, other goods, and other services. Using annual post-war British data from 1954 to 1974, they concluded that the AIDS is capable of explaining a high proportion of the variance of the commodity budget shares. They estimated the original AIDS model as well as the AIDS' model linear approximate

version in the first difference form. The parameter estimates from the latter are rather close to the estimates obtained from the original model, homogenous or unconstrained.

Blanciforti and Green (1983) analyzed the AIDS for four food groups and compared the estimates with AIDS' linear approximate version and the linear expenditure system (LES) using annual U.S. time series data for 1948-78. Their study focused on comparing the three models for four food groups, namely, meats, fruits and vegetables, cereal and bakery products, and miscellaneous foods. The estimated expenditure elasticies differ greatly between the AIDS and the LES. More so, their analysis demonstrated that AIDS is a more viable system for analyzing the demand for food commodities. Also, the linear approximate version with homogeneity imposed performs reasonably well with respect to estimated magnitudes of elasticities.

Heien and Wessells (1988) applied the AIDS modified to incorporate demographic effects and analyzed demand for dairy products. The structure of dairy product demand is estimated using Household Food Consumption Survey data. Then using the demand relations estimated from cross-section data, prediction interval tests utilizing time-series data are performed for milk and butter. The results showed that demographic effects, especially household members by age and sex, and the proportion of meals eaten at home, are highly significant variables. Furthermore, results indicated that the demands for dairy products are generally inelastic, cross-price effects are moderate and income effects are small and negative.

In a study by Eales and Unnevehr (1988), dynamic version of the AIDS is applied to estimate two meat demand systems in the US. The first system includes meat aggregates (chicken, beef and pork); the second system disaggregated meat

products into whole birds and parts/processed products, and beef into hamburger and table cuts. The study performed tests of weak separability by animal type; their tests concluded that consumers choose among meat products rather than meat aggregates. All demand equations are then tested for structural change. Their results showed presence of structural change in the chicken parts demand and beef table cut demand. Eales and Unnevehr (1988) concluded that the increased demand for convenience might explain these structural changes of demand.

Moshini and Meilke (1989) employed a four-meat AIDS with parameters following a gradual switching regression model. Their study focused on testing the hypothesis of structural change in U.S. meat demand. Quarterly data over the period 1967 to 1987 are used. The result supports the notion that structural change partly explains the observed U.S. meat consumption patterns. Structural change is biased against beef, neutral for pork, in favour of chicken and fish, and it does not affect estimated elasticities.

Hayes, Wahl and Williams (1990) tested three hypotheses regarding meat-consumer behaviour in Japan: the separability of meats and fish, the perfect substitutability of local (Wagyu) and import-quality beef, and the net substitutability of meats. The tests were new and developed for the linear version of the AIDS. Their results revealed weak separability between meats and fish, rejection of hypothesis that local and imported beef are perfect substitutes and finally, evidence of net complimentarity between chicken and dairy beef and chicken and pork.

Chen and Veeman (1991) analyzed Canadian meat consumption patterns using the dynamic version of the AIDS. Quarterly time series data for the period starting 1967 to 1987 are used. Structural change in the demand for meats is

examined and concluded that Canadian consumption patterns can be explained by a combination of habit persistence, changes is prices, consumer expenditures and tastes. Empirical estimates from the model indicate that the demand for chicken is more expenditure elastic than for beef and pork. Also, the performance of the static and dynamic AIDS specification is compared. The properties of homogeneity and symmetry implied by consumer theory are rejected in the static model, whereas these properties are not rejected in the dynamic model.

Ahmed and Shams (1994) estimated a complete demand system for rural Bangladesh applying the AIDS model. Demand parameters are analyzed based on primary data from the rural household survey conducted by International Food Policy Research Institute (IFPRI) in 1991/1992. Their study suggested that rural households in general are highly responsive to changes in income in adjusting their consumption patterns. Demands for commodities are also responsive to changes in their own-price, with the exception of salt. The estimates of cross-price elasticities indicated that substitution effects are strong, and have important implications for price policies.

Fayyad, Johnson and El-Khishin (1995) studied the structure of consumer demand for major foods in Egypt. The LA/AIDS model is applied in estimating price and expenditure elasticites for 21 food commodities. Price elasticities were computed using time series data for the period 1981 to 1992, whereas the expenditure elasticites are estimated from a cross-section data.

Schroeder, Marsh, and Mintert (2000), analyzed beef demand determinants in the U.S. by estimating a meat demand system. Their study used quarterly time series data over the 1982 to 1998 period. The system employed the AIDS model and included changing consumer demographics, food safety problems, health information,

and seasonality. The impacts of individual demand determinants on beef were calculated each year from 1992 through 1998 in sample and 1999 out-of-sample. Result of the study found beef to have an inelastic demand with an own-price elasticity of –0.61. Pork and poultry are both weak substitutes for beef with cross price elasticities of 0.04 and 0.02 respectively. Health information weakened beef demand by about 0.60% annually during the study period. Whereas, increasing female labour force participation had a strong negative impact on beef demand and has benefited poultry demand.

Duffy (2003) applied an advertising-augmented version of the AIDS to model long run demand for seven disaggregated product categories. The study tested the influence of advertising on the inter-product distribution of consumer demand for non-durable goods and services in the UK, from 1963 to 1996. Results indicated that restrictions of price homogeneity and symmetry are consistent with the data. The demand elasticity estimates are in general plausible, and confirm the strong influence of prices on the allocation of consumer expenditure. And there is little support for the hypothesis that advertising has the power to effect marked changes in the inter-product pattern of consumer demand in the UK.

Mazzocchi (2003) provided a generalization of the structural time series version of the Almost Ideal Demand System (AIDS) that allows for time-varying coefficients (TVC-AIDS) in the presence of cross-equation constraints. An empirical appraisal of the TVC-AIDS is made using a dynamic AIDS with trending intercept as the baseline model with a data set from the Italian Household Budget Survey (1986--2001). The assessment is based on four criteria; adherence to theoretical constraints, statistical diagnostics on residuals, forecasting performance and economic meaningfulness. No

clear evidence is found for superior performance of the TVC-AIDS, apart from improved short-term forecasts.

And more recently, Mazzocchi (2004) applied the dynamic AIDS model with stochastic shift on Italian data, to model consumer reaction to multiple food scares. The data covered quarterly time series from 1986 to 2000. The study assessed the time-varying impact of two waves of the BSE crisis and the dioxin crisis in between. Empirical results showed the scarce relevance of the dioxin crisis in terms of preference shift.

3.3 Rotterdam Model

The Rotterdam model was proposed by Barten (1964) and extended by Theil (1965). Practical applications of this model have been widely used to test empirical validity of the restrictions of demand theory (Deaton and Muealbauer 1980b; Tridimas 2000). Barten (1967) carried out the first tests of homogeneity and symmetry employing Dutch Data. He applied the Rotterdam model to analyze four broad groups. The study found little conflict between the data and the theory. However, the study used informal testing procedures.

In another study by Barten (1969), he estimated the Rotterdam model with the addition of intercept terms to measure for gradual changes in tastes. The study also carried out tests of homogeneity and symmetry using the Dutch data for 16 groups of goods. The study is much more detailed than the 1967 study and adopted an explicit maximum likelihood approach. Results of the study found conflict between theory and evidence, tests of homogeneity and symmetry are both rejected in this study.

Deaton (1974) also employed the Rotterdam model using nine distinguished groups of goods to analyze consumer demand in United Kingdom from 1900 to1970,

excluding war years. The nine groups of goods include food, footwear and clothing, housing and household, fuel and light, drink and tobacco, travel and communication, entertainment, other goods, and other services. Theoretical restrictions were tested and found that homogeneity of demand is in clear conflict with evidence, but symmetry as an additional restriction is accepted.

Just like other complete demand systems, the Rotterdam model is also used to estimate elasticities. Mann (1980) applied the Rotterdam model to analyze personal consumption expenditure data for 1949 to 1977. A full matrix of direct and cross-price elasticities and income elasticities was estimated. In the study, 12 categories of expenditures were examined, these were: food at home, food away from home, alcohol and tobacco, clothing, housing, utilities, transportation, medical, durables, other nondurables, services, and miscellaneous.

Kinnucan et al. (1997) analyzed U.S. meat consumption pattern from 1976 through 1993. The Rotterdam specification is used and augmented with advertising and health information effects to determine whether these variables have detectable effects on US meat demand. Also, an intercept is included in the system to test whether trend-related changes in demographics or meat composition affect meat demand. The demand system consists of meat equations for beef, pork, poultry (chicken and turkey) and fish. Their study suggested that health information or trend was significant in each four meat equations. Moreover, the health information elasticities in general are larger in absolute value than price elasticities, which suggest that small percentage changes in health information have larger impacts on meat demand than equivalently small percentage changes in relative prices. The estimated effects of generic advertising, in contrast, were found to be modest and fragile.

In the study of Schmitz and Wahl (1998) the Japanese wheat import allocation decision is analyzed using the Rotterdam model. Homogeneity and symmetry restrictions are imposed in the study and found that the restrictions do not hold. The income elasticities have indicated that the Canadian and U.S.A brand of wheat were highly income elastic and the income elasticity varies significantly across time periods.

Xiao, Kinnucan and Kaiser (1999) applied the Rotterdam model to analyze the effects of advertising on the demand for non–alcoholic beverages in the U.S.A from 1970 to 1994. Five types of beverages were analyzed in the study. The study revealed that advertising appears to play a minor role in explaining the beverages consumption pattern in the USA. Also, the study found demand for non–alcoholic beverages were inelastic. In addition, income elasticities were between zero and one, which suggests that the beverages were normal goods.

Lastly, Kaabia, Angulo and Gil (2001) estimated a cointegrated CBS model, which is a variant of the Rotterdam model. Their study aimed to analyze whether the increasing number of information on the relationship between diet and health has had an impact on the demand for different types of meat and fish in Spain. In the study, elasticity estimates for meat demand and health information are calculated. Results showed that, in the case of Spain, health information elasticities are significant, and have a positive effect on fish and poultry and a negative impact on beef and pork.

3.4 Model Selection

The Rotterdam and the AIDS models are different demand specifications, which have different implications. The two models lead to different results in some applications. The popularity of these models is evident in their extensive use. The

literatures above points to their wide adoptability especially in food demand studies. However, neither economic theory nor statistical analysis provides clear *a priori* criteria for choosing between these two models (Lee, Brown, and Seale 1994). In most of the literatures cited above, the choice of the model is made arbitrarily.

The reason for the lack of formal direct comparison specifically between the Rotterdam model and the AIDS is that these demand equations are non-nested within each other, that it is not possible to represent one model as a special case of the other (Tridimas 2000). Ex-post analysis via statistical tests from estimating both models may suggest one is preferable but these kinds of comparisons are necessarily incomplete. Thus, when comparing these models, one needs an alternative procedure for the competing alternatives (Lee, Brown, and Seale 1994).

Some studies had compared and developed a formal test between different demand systems. Deaton (1978) applied a non-nested test to compare demand systems with the same dependent variables, but his test is not applicable when comparing the Rotterdam and AIDS because they have different dependent variables (Lee, Brown, and Seale 1994).

Davidson and Mackinnon (1981) proposed the *J-test* to compare and explicitly test the validity of a model against another non-nested model. This test also requires that the competing models have identical dependent variables.

Alston and Chalfant (1993) compared and developed a pairwise non-nested test for models with the same independent variables but different dependent variables. Their study showed that the Rotterdam model fits better than the AIDS in their application to U.S. meat demand.

Barten (1993) developed pairwise and higher-order tests to choose between the AIDS, the Rotterdam, and the Hybrids of the AIDS and the Rotterdam. The study showed that the Rotterdam and the AIDS are special cases of a more general demand system.

Lee, Brown, and Seale (1994) tested alternative demand systems combining the four versions of differential demand systems, including the Rotterdam and AIDS models, and two mixed models, the CBS system and NBR system. A general model that nests all four models is developed to help select the best-fitted model for the data. Their result suggested that AIDS income and price responses better explain Taiwanese expenditure behaviour than other models.

Kastens and Brester (1996) compared the absolute price version of the Rotterdam model, the FDLAIDS and a first differenced double-log demand system on the basis of its forecasting ability. Using annual U.S. per capita food consumption, a double-log demand system is a superior forecaster compared to the Rotterdam model, which is superior to the FDLAIDS.

Despite the large body of theory, the number of available literature on non-nested tests, and their application is still sparse (Greene 2000). Discussed below are the few studies, which have compared the Rotterdam and the AIDS, and studies that have utilized the above methods of model selection by a non-nested hypothesis test.

Jung and Koo (2000) in their study of the structure of Korean meat and fish product demand compared the LA/AIDS and Rotterdam model to determine which of the two models is more appropriate. Using the compound model approach of Alston

and Chalfant (1993) their study indicated that the LA/AIDS fits better than the Rotterdam model.

In the study made by Tridimas (2000) in analyzing the pattern of consumer demand in Greece, he adopted the *J-test* of Davidson and Mackinnon (1981). The study, converted the AIDS specification into a form that is consistent with that of the Rotterdam model and obtained the General Dynamic specification of the AIDS. His findings show the General Dynamic model of the AIDS fits better than the Static AIDS and the Rotterdam model.

Fousekis and Revell (2002) analyzed the farm level demand for pig meat, beef and lamb in the U.K. They performed model selection among competing inverse systems namely the inverse Rotterdam (RIDS), the inverse CBS, the Inverse Differential AIDS (IAIDS), and the inverse Neves' system (NBRIDS) following the procedure of (Lee, Brown, and Seale 1994). The empirical results showed that the inverse AIDS performs better than the competing systems.

3.5 Meat Demand Studies in Malaysia

Empirical research on demand for meat receives little attention among researchers in Malaysia. Some earlier demand studies on fish and meat utilize a simple linear relationship that do not satisfy the underlying properties of a demand function and in most cases fail to provide proper estimates of own–price and income elasticies (Abdullah 1994).

However, few studies have been conducted which properly adopted some well known demand systems. Abdullah (1994) estimated both static and the dynamic AIDS

to analyze the demand for fish and meat products in the country using time series data from 1960 to 1990. His result showed that the dynamic AIDS performed better than the static version. The estimated own-price elasticities indicate that fish, pork and beef are price inelastic whereas chicken is price elastic (-1.01). The expenditure elasticies for fish and the meat groups are found to be necessities. The cross-price elasticities indicate that fish is a substitute for chicken and pork, and all other meat products tend to complement each other.

In an earlier study, Baharumshah (1993) used LA/AIDS model using annual meat consumption data from 1960-1990. The uncompensated own-price elasticities were elastic for chicken, pork and fish. Gross complementarity among meat groups was also observed since a large portion of the uncompensated cross-price elasticities were negative. Most importantly, the study found that fish, beef and mutton have acquired an important position in the diet of Malaysians as indicated by their high expenditure elasticities and low own-price elastiticies.

A recent study by Milad (2004) adopted the Rotterdam model using data from 1970-2000. Both single equation estimation and systems of equation estimation method were employed in the analysis. Beef, mutton and pork were found to be necessities while chicken is surprisingly a luxury. In addition, the uncompensated own-price elasticities for beef and mutton are positive which do not conform to the negativity theory of demand.