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Canadian Household Demand for Food

by

Chen Chen ©

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Abstract

This thesis examines the impact of socioeconomic and demographic factors on Canadian household decisions to consume food-away-from-home, food-at-home, convenience food, prepared meals, and snacks, using Canadian Family Food Expenditure Survey data for 1986 and 1992.

The study applies both single-equation and demand system approaches to estimate the determinants of food demand. Heckman's two-stage procedure is employed to correct for the selection bias from zero expenditure. The intra-household behavior on food expenditures is also investigated using a sub-sample grouping method.

The results indicate that the employment status, gender of household head, marital status, immigrant arrival year, presence of children, and number of full time earners have a strong impact on household demand for food besides the effects of price, income and household size. Household size elasticities are larger than price and income elasticities. Sub-sample results indicate that intra-household allocation could be an important factor in household decision on food expenditure.

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Chapter 1 Introduction

1.1 Background

Food expenditure patterns of Canadian households have greatly changed during the past 30 years. Data from the 1969 Canadian Family Food Expenditure Survey indicated that Canadian households spent only 15% of their food budget on food purchased from restaurants. By 1982, this proportion had climbed to 25%, reached 28% in 1996, after peaked at 30% in 1992 (Statistics Canada 1996). Over the past fifteen years, a wider variety of convenience food and prepared meals has become available to consumers. Different types of snacks (including fruit, yogurt, vegetable juice, etc.) have gained favor by consumers largely due to interests in healthy foods. The food industry in Canada has undergone a startling transformation in only a few decades. As a result, the industry has witnessed significant development in the food-away-from-home and prepared food sectors. From both theoretical and marketing perspectives, it is of interest to examine the determinants of demand for various food categories, such as food-away-from-home, convenience food, prepared meals and snacks.

Compared to the extent of cross-sectional research on US household food demand, few studies have rigorously examined the determinants of the expenditure patterns of Canadian consumers. Most previous Canadian studies have focused on the analysis of aggregate food demand using time-series data, rather than disaggregated demand with cross-sectional data. Changes in food prices and increases in income have been the predominant explanatory factors in time-series studies. Emphasis is usually placed on testing for possible structural changes in demand (e.g. Moschini and Moro 1993, Chen and Veeman 1991, Reynolds and Goddard 1991, Xu and Veeman 1996). To gain a comprehensive understanding of food consumption patterns in Canada, analysis of demand using household level micro-data and assessment of effects of factors in addition to price and income are required (Eales and Unnevehr 1993).

1.2 Research Problems

The research problem addressed in this study is to identify the impact of socioeconomic and demographic factors on Canadian household demand for various food categories.

Beyond commodity prices and household income, socioeconomic and demographic influences that can be reflected by index variables are useful tools for market segmentation and target marketing. The food expenditure patterns of Canadian households and the classification of major food categories are also topics of research interest because knowledge of these features will allow improved understanding of food demand in Canada. The changing social and cultural environment on food demand as well as the economic situation reflected by price and income will be investigated, and their significance will be evaluated.

1.3 Objectives

The general objective of this study is to provide a better understanding of the determinants of the Canadian households' expenditure decisions on major food categories. Three specific objectives are the following:

1. To describe food expenditure patterns of Canadian consumers;
2. To measure the impact of socioeconomic and demographic variables on the demand for major food categories;
3. To develop marketing implications from 1 and 2 for the Canadian food industry.

1.4 Data

The data used in this study come from the Canadian Family Food Expenditure Survey (FFES). The Household Surveys Division of Statistics Canada has conducted the survey every two years since 1953, and subsequently published these data. To undertake a detailed analysis of Canadian household food demand and to assess the impact of changes during the most recent years, we chose to use the 1986 and 1992 FFES data. The FFES data for 1996 had not been released at the time of completion of this thesis; hence, this study uses data from earlier surveys. The data set is from a large micro survey containing data on 10,919 households for year 1986, and on 10,848 households for 1992. Information on more than 60 socioeconomic variables and over 200 detailed food items is recorded.

1.5 Methodology

The main research methodology is using Heckman's two-stage procedure with both single equation and demand system to estimate the effect of socioeconomic determinants on Canadian household demand for food. To achieve the research objectives, Canadian expenditure on food is first classified into five types: food-away-from-home (FAFH), convenience food (COV), prepared meals (MEAL), snacks (SNK), and food-at-home (FAH, including all the rest). Detailed food items are then aggregated into these categories and prices are adjusted for subsequent demand estimation purposes. Based on household production theory, both single equation demand functions and systems of demand equations are derived. To eliminate the quality effects embodied in unit price values in survey data, aggregated price indices for different food categories are adjusted before incorporating into demand estimation. To correct for sample selection bias that arises from zero expenditure problems encountered in the household survey data, Heckman's two-stage estimation procedure is adopted.

In the first stage of estimation, a Probit model of household purchase participation decision is estimated, from which an inverse Mills ratio is obtained for every sample observation. In the second stage of estimation, the inverse Mills ratios is incorporated into demand equations as an independent variable along with other determinants. This procedure allows the purchase participation probability to be embodied into either single equation or system of demand functions, and the factors affecting zero consumption households are taken into account in the second stage demand estimation. Namely, the selection bias resulting from non-consuming households is corrected. The single equation demand estimation for each food category is conducted by regressing food expenditures on socioeconomic variables and prices. Linear and restricted versions of the Almost Ideal Demand system (the AIDS Model) by Deaton and Muellbauer (1980) are adopted for system estimation.

In addition to the traditional approach of demand estimation often referred to as the unitary approach, in which the population is viewed as a whole, the sample data are also divided into several sub-samples related to women's labour force participation and the presence of children. This enables testing of "collective" concept demand models, in which purchase decisions may be made collectively by household members rather than household head. Demand estimation is carried out for each sub-sample to investigate the effects of differing household compositions and possibilities of intra-household differences in preference allocations. The specific socioeconomic and demographic variables pertaining to each person in the sampled households are incorporated into this demand model in the estimation equation to test their significance. Outcomes from these sub-sample models are compared with the whole sample to explore whether observed choices are consistent with those suggested by traditional demand theory.

1.6 Organization

This thesis consists of seven chapters. The first chapter outlines the background of the study, research problem, objectives, data sources and methodologies. The second chapter contains a literature review pertaining to previous studies on the demand for various classes of food, and empirical problems of cross-sectional studies that include zero expenditure and price adjustment. The incorporations of socioeconomic and demographic variables are reviewed as well as are recent developments in collective model approaches to household demand. In Chapter 3, the theory and empirical framework are introduced. Household production theory is interpreted and the derivation of the postulated demand functions is presented. Demand functions are considered in both single equation and the almost ideal demand system (AIDS model) frameworks. Empirical models with socioeconomic variables and sample selection correction (Inverse Mills Ratio) are also discussed. Chapter 4 provides a description of the data, the classification methods, and a discussion of price adjustment. The structure of the FFES data and the classification of various food categories are discussed in detail. Some important statistics are calculated and price adjustment processes are also detailed in this chapter. Chapters 5 and 6 provide the detailed estimation results and elasticities calculated from single equation and demand system estimation. Comparisons of sub-sample estimation relative to particular socioeconomic and demographic variables are also given here. Chapter 7 summarizes the findings of the study, outlines marketing implications for the food industry, and contains recommendations and suggestions for further research and concluding statements.

Chapter 2 Literature Review

The determinants of Canadian household demand for food in its various marketed forms[1] that relate to the place of consumption and convenience factors are the focus of research interest for this study. Review of previous studies of demand relating to the identified food categories is presented in the first section of this chapter. Cross-sectional demand estimation with micro-data is the major empirical focus; hence, relevant studies are also reviewed in this section. In the second and third sections, empirical data problems, including zero expenditures and quality adjusted prices are discussed. The fourth section addresses empirical specifications of socioeconomic and demographic variables in demand studies. Finally, previous studies that are based on collective models of household behavior are discussed.

2.1 Previous Studies of the Demand for Classified Food

2.1.1 Demand for Food-away-from-home

Food-away-from-home consumption has received much attention from researchers over the last few decades, as eating out has become increasingly popular in North America. In early studies of FAFH, McCracken and Brandt (1987) found that an important determinant of FAFH consumption is household real income. There is a tendency in North America for the expenditure elasticity with respect to income for FAFH to be somewhat bigger than the analogous income elasticity for Food-at-home (FAH) (Lamm 1982). Socioeconomic and demographic trends are also frequently cited as potential influences on FAFH consumption. Factors such as age, ethnicity, region, urban residence, and education may have potential effects on FAFH consumption due to differences in preferences, availability, and price (Prochaska and Schrimper 1973; Kinsey 1983; McCracken and Brandt 1987; Lee and Brown 1986; Yen 1993; Nayga and Capps 1992). Increased participation of women in the labour force places time constraints for people to prepare meals at home. Many studies have emphasized the influence of working women

1 Including food-away-from-home, food-at-home, convenience food, prepared meals and snacks.

on household food expenditures (Redman 1980, Kinsey 1983, Nayga and Capps 1992, Yen 1993). One main finding of recent studies is that education levels of working women positively influence FAFH consumption (Yen 1993, Nayga 1996).

In terms of estimation, almost all studies except for those based on aggregate data have employed limited dependent variable regression techniques. The limited dependent variable techniques have involved the Tobit model (Reynolds and Goddard 1991), Cragg's double hurdle model (Yen 1993), generalized Heckman' procedure (Park and Capps 1997), and switching regressions (Lee and Brown 1986). Demand for FAFH has been estimated in a single equation (Reynolds and Goddard 1991, Byrne et al 1996) or as a part of a demand system (Nayga 1996). Previous studies indicate that FAFH is relatively inelastic with respect to income and household size. The elasticities of income and household size from selected studies are presented in Table 2.1.1. Only Reynolds and Goddard's (1993) study using Canadian data obtained the negative household size elasticities, indicating the expenditure patterns of Canadians may be different from those of Americans. Price elasticities for FAFH are not commonly reported in previous studies. The general limitation of previous studies on FAFH is that some omit elasticities for relevant socioeconomic variables and the fact that most of the studies are based on a single-equation approach.

Table 2.1.1 Previous Estimates of Income and Household Size Elasticities for FAFH

Author(s)	Data Coverage	Data Source	Income Elasticity	Household Size Elasticity
Lamm	1960-80	USDC	0.11	N/A
McCracken and Brandt	1977-78	USDA NFCS	0.24	0.27
Yen	1989	BLS-CES	0.36	0.24
Byrne et al.	1982-1989	USDA NPD	0.21	0.32
Nayga, Jr.	1992	BLS-CES	0.32	N/A
Reynolds and Goddard	1986	FFES	0.60	-0.29

Note: All Income elasticities are based on quantities except Nayga' s study which is based on expenditure.

USDC: United States Department of Commerce

USDA NFCS: United States Department of Agriculture Nationwide Food Consumption Survey

BLS-CES: US Bureau of Labour Statistics Consumer Expenditure Survey

NPD: National Panel Diary Group Survey, provided via USDA

FFES: Family Food Expenditure Survey, Statistics Canada

2.1.2 Demand for Convenience Food and Prepared Meals

Research on demand for prepared meals and convenience food has been developed along with the introduction of these foods in the marketplace. Capps et al (1985) employed the Almost Ideal Demand System with NFCS[2] 1977-1978 survey data to analyze household demand for convenience foods in the United States. This study found that budget shares were more responsive to prices than to total food expenditure. It was also found that the quantities demanded of convenience and nonconvenience foods were more sensitive to income and own price than to cross-prices. The own-price elasticities for convenience food ranged from -0.4558 to -0.8491 and the elasticity for non-convenience food was -0.2205. The total food expenditure elasticities for convenience food ranged from 0.86 to 1.03 and the elasticity for non-convenience food was 1.05. These authors concluded that the primary users of convenience foods were white households with employed household managers[3] of less than 35 years of age. Households with female managers assigned larger shares to nonconvenience foods and smaller shares to convenience foods than households with male managers. Households with college-educated managers allocate smaller shares of the food dollar to nonconvenience foods but larger shares to convenience foods than households without college educated managers. Further results indicated that the increased household size did not lead to an increase in convenience food consumption. The income elasticities for convenience food ranged from 0.2785 to 0.3403 and it can thus be considered a necessary good. The elasticities of total food expenditure ranged from 0.8621 to 1.0534. Although a demand system was used in this study, the selection bias problem was ignored and the unit values[4] were used to approximate price.

Park and Capps (1997) adopted a single equation Heckman two-stage procedure in estimating the demand for prepared meals by U.S. households with NFCS 1987-1988 survey data. Selection bias corrections and quality-adjusted prices were considered in this estimation. The own-price elasticities estimated for prepared meals ranged from -0.2303 to -0.6570 and the income elasticities for this category ranged from 0.0702 to 0.1317. The findings suggest again that prepared meals are a necessity. The study found that

2 United States Department of Agriculture Nationwide Food Consumption Survey

3 Defined as person in household who controls income and spending.

4 Unit value = expenditure /quantity

households headed by younger, more educated, and time-constrained managers were more likely to purchase prepared meals. Expenditures on prepared meals are principally affected by male household members. The presence of teenagers of either gender in a household is also positively associated with expenditures of prepared meals.

2.1.3 Demand for Snacks and Food-at-home

Expenditure on snacks has rarely been classified as a unique category in previous research on food demand. Although some early studies focused on particular categories of snacks, such as fruit (Green 1991), most researchers to this point have not categorized snacks as a separate group to be analyzed in detail. Park and Capps (1997) classified snacks as a unique group of food items which are consumed between meals or for dessert. Although their study focused on prepared meals and it did not further investigate snacks, the classification method used in their study clearly outlined a categorization of snacks. We follow their approach in this study to classify snacks.

Although previous studies on demand have classified food-at-home as a unique category other than food-away-from-home and prepared meals (Yen 1993, Park and Capps 1997, Nayga and Capps 1992), only a few rigorously estimated the coefficients and elasticities for the FAH category. Capps et al (1985) explicitly provided price elasticities for non-convenience food (-0.22). Nayga (1996) estimated the expenditure elasticities with respect to income for food-prepared-at-home to be equal to 0.11. Some studies of individual food-at-home items can be found in the demand analyses for particular commodities such as cheese, meat and fish (Gould 1992, Yen and Jones 1997, Cheng & Capps 1992). However, none of these studies provided estimates for the aggregate food-at-home category.

2.1.4 Demand for Classified Food Groups

One of the recent comprehensive studies on demand for different food categories was done by Nayga (1996). This study investigated the influence of various socioeconomic characteristics on family expenditures, emphasizing the impact of women's participation in the labour force on expenditure for prepared food[5], FAFH, and food at home. The

5 This category includes convenience food and prepared meals.

uniqueness of this study is that it looks at all three types of foods using the same data set.[6] The findings are that as education of women increases and they participate more in the labor force, expenditures on food-away-from-home and prepared food increase. The expenditure elasticities with respect to a woman's labour hours per week for prepared food, FAH and FAFH are 0.058, -0.021 and 0.129, respectively. The tendency overall is towards more expenditure on FAFH than on prepared food. These results are slightly different from those obtained by Redman (1980), who concluded that the participation of women in the labour force increases more expenditures on prepared food than on FAFH. The model estimation in Nayga (1996) was done in two steps, following Heckman (1979). Inverse Mills ratios were calculated for three expenditure equations and then in the second step, these equations were estimated as a system. The econometric approach was generalized by using all observations in the second step. However, a drawback of Nayga (1996)'s study is that no prices were used or, more precisely, they were assumed to be the same for all households.

2.1.5 Canadian Studies of Cross-sectional Demand with Micro-data

The focus of this study is to explore Canadian food demand with micro-level disaggregated data using appropriate statistical techniques. The Family Food Expenditure Survey (FFES) data are used in this research. Previous studies based on FFES data have mainly been restricted to ordinary least squares (OLS) method (Horton and Campbell 1991) and few comprehensive econometric analyses considering selection bias have been conducted. Horton and Campbell (1991) investigated the effects of spousal employment on food expenditure and apparent nutrient intake using 1984 FFES data by estimating single demand equations using OLS. Their study indicates that households in western provinces and headed by university educated people have a positive influence on FAFH. The increase in per capita income, women's participation in the labor force, as well as decreases in household size and number of children, will increase the share of food-away-from-home in the food budget. However, their study did not report the estimated coefficients of prices and calculated elasticities. In working papers by Reynolds (1991) and Reynolds and Goddard (1991), the effects of socioeconomic and demographic

6 The data were obtained from the US Bureau of Labour Statistics 1992 Consumer Expenditure Survey.

variables on demand for fluid milk and for FAFH are examined using 1986 FFES data with Tobit modeling techniques. Reynold and Goddard (1991) found that households headed by younger, male heads, with higher incomes, fewer children, and smaller household size generally have positive influence on FAFH expenditure. Households residing in Alberta spend the most on FAFH, while households in the Atlantic province spend the least. The second and third quarters are the favorite season to eat out. The computed income and household size elasticities for FAFH are 0.5982 and -0.2905 respectively. In general, the above Canadian studies adopt earlier models and do not explicitly consider alternative approaches such as Heckman's two-stage method that may be more appropriate to analyze household decisions. Almost no previous studies on Canadian data have rigorously investigated demand of food categories other than FAFH. In contrast, microdata has been extensively used for American demand analysis on various food categories with correction for selection bias. The use of household-level microdata can avoid the problem of aggregation over consumers and provides a comprehensive statistical sample (Heien and Wessells 1990). Hence, cross-sectional analysis is employed in this thesis and is applied to Canadian data. However, some empirical problems are normally encountered in micro survey data and they must be considered, including zero expenditures and the need for price adjustments.

2.2 Problem of Zero Expenditure

2.2.1 The Problem

A common problem in cross-sectional demand analysis for non-durable goods (e.g. food) is the zero expenditure issue. Household food expenditure surveys commonly record purchases over a relatively short period. For example, the Family Food Expenditure Survey (FFES) of Canada is constructed from diary records of expenditures over a period of two weeks. For such a brief interval, a substantial number of households may report not purchasing a particular product (zero expenditure) during the survey period. When data are detailed into specific food groups, most notably tobacco and alcohol, a more considerable number of zero expenditures entries will occur. The proportion of households which are likely to report not purchasing a product during a survey term increases as the category becomes more specific or as the survey period becomes shorter.

For instance, there would be more zero expenditures reported for beef than for meat and more for ground beef than for beef, and the number of zero expenditures would increase further if the survey period was reduced from two weeks to one week.

For the demand analyst, zero expenditures pose both a conceptual issue concerning underlying causes and a statistical problem regarding appropriate econometric methodology. Typically, the reason for zero expenditures cannot be easily determined from the available survey data.

2.2.2 Reasons

There are several possible reasons for the occurrence of zero expenditures. Zero observations normally arise from three main sources: *The first category* is non-consumers who would simply never buy the particular food commodities, based on health concerns, religious beliefs, taste preferences or other reasons. These households can be excluded from the analysis since they would never be part of the market (Thomas, 1972, pp. 125-126). This type of zero expenditure is often named *abstention*.

With *the second category* of households, infrequent buyers, zero expenditures are reported because of the short duration of the consumer survey. The survey period is too short to register these households' purchases. People tend to seek variety in their diet. If the survey period had been extended, fewer non-purchases would have been reported. Food inventories in the household can also be a factor in these periodic purchases. Many food products, such as potatoes, are purchased in sufficient quantities to be stored and consumed over an extended period by the household. This type of zero expenditure is thus called *infrequency*.

The third category can be described as potential buyers. These households might buy a certain food commodity if some economic factor changed, such as lower prices or increasing household income. The potential buyers represent a corner solution to the conventional utility maximization problem. Therefore, the reason for this type of zero expenditure is often referred as *corner solution*.

Because the zero expenditure problem occurs for differing reasons, sample data with zero expenditures cannot be regarded to be equivalent to other types of data in the analysis of survey data. A household expenditure survey that is conducted over brief intervals may give a misleading impression of underlying consumption patterns if we simply regard zeros as an indication of nonconsumption. In fact, the situation created by zero expenditure in demand analysis is an example of the more general econometric problem of limited dependent variables, which is concerned with truncation and censoring. The effect of truncation occurs when sample data are drawn from a subset of a larger population. A truncated distribution is the part of an untruncated distribution that is above or below some specified value. Censoring of the dependent variable means that values in a certain range are all transformed to (or reported as) a single value. The zero expenditure problem can be considered an issue of sample selection or incidental truncation; the data in such a survey are incidentally truncated, or nonrandomly selected. Due to a lack of attention paid to the problem, ordinary least squares (OLS) method has sometimes been used to estimate demand relations with data that contained substantial numbers of non-purchasers. This is still frequently used and it can yield biased and inconsistent estimates (Amemiya 1974, Cragg 1971, Pudney 1989 and Maddala 1983). In situations in which the zero expenditure issue is relevant, the models for conducting cross-sectional demand analysis are limited dependent variable methods such as truncated regression and censored regression methods.

2.2.3 Econometric Modeling with Zero Expenditure

2.2.3a Overview of Different Model Choices

The zero expenditure problem posed by non-purchasers can be approached as an issue of sample selection bias, or an *incidental truncation* problem: Do the purchasers and non-purchasers represent random sub-samples of the entire sample of households or does the self-selection involved yield non-random samples? In terms of the three categories of recorded zero expenditures discussed above, infrequency of purchase would likely yield random samples, whereas true non-consumers and potential consumers might produce select (non-random) samples. However, it also might be the case that certain households that purchase a product less frequently are different from those who buy it more regularly. The selection criterion in instances of zero in the expenditure survey data for true non-consumers and potential buyers does not necessarily exclude individuals who are infrequent buyers. Under such circumstances, zero expenditure problems can be specified as a form of incidental truncation (sample selection).

Many methodologies have been developed since the late 1960s to deal with the problem of truncated and censored data. Some methods allow researchers who studies demand to correct for selection bias. Most of the underlying methods deal with single demand equations while system issues are not often covered. The Tobit model (Tobin 1958) has often been used. One restrictive feature that renders the Tobit model unpalatable for empirical analysis is the nature of its parameterization. In particular, the Tobit model treats observed zeros as true non-consumption and implies that the probability and level of consumption are determined by the same sets of parameters and variables. Such parameterization has been rejected in food demand analyses (Jones and Posnett 1991, Reynolds 1990).

Cragg (1971) and Atkinson et al. (1984) proposed the double-hurdle model, which generalizes the Tobit parameterization. The double-hurdle model features two separate stochastic processes that determine the probability and conditional level of consumption and account for zero observations resulting from true economic non-consumption as well as other factors such as conscientious abstention (Pudney 1989). However, in the case of cross-section data that are typically collected in short-duration surveys, other non-behavioral factors such as infrequency of purchases cannot be ruled out as the cause of zero observations. Deaton and Irish (1984) and Blundell and Meghir (1987) proposed a framework for modeling demand with zero observations resulting from infrequency of purchases. The probability of purchase infrequency is explicitly specified and incorporated into the Log-likelihood function of the model.

Another aspect of the limited dependent variable (LDV) models that has received relatively little attention in empirical applications relates to the error distribution. In particular, the Tobit, double-hurdle, and infrequency-of-purchase models have commonly been estimated under the assumption of homoscedastic and normal errors. However, in LDV models, maximum-likelihood (ML) estimation produces biased and inconsistent parameter estimates when the errors are heteroscedastic (Arabmazar and Schmidt 1981) or non-normally distributed (Arabmazar and Schmidt 1982). Evidence of nonnormal and heteroscedastic errors in the Tobit model has been reported in food demand analysis (Reynolds and Shonkwiler 1991).

Nonnormal error distributions have been proposed for the Tobit model. Examples include the exponential Tobit (Maddala 1983), the Gamma Tobit (Atkinson et al. 1990), and the lognormal Tobit (Amemiya and Boskin 1974) models. Like the standard Tobit, these models are subject to the restrictive Tobit parameterization and specific error distributions. Hence they are subject to specification errors. Lankford and Wyckoff (1991) used the Box-Cox Tobit model in modeling charitable giving, in which normality of errors was relaxed but the Tobit parameterization and homoscedasticity of errors were maintained.

Poirier (1978) proposed the Box-Cox transformation in a specification that nests a range of popular LDV models, including the double-hurdle model. The model proposed by Poirier (1978) features double-hurdle parameterization and nonnormal errors, but homoscedasticity of errors are maintained. In short, models that generalize both the parameterization and distributional assumptions of the Tobit model are rare.

Su and Yen (1996) applied the inverse hyperbolic sine (IHS) transformation to the heteroscedastic double-hurdle and infrequency-of-purchase models in empirical demand analysis for pork. The resulting specifications feature flexible parameterization and nonnormal and heteroscedastic errors. They considered different sources of zero consumption and estimated both the IHS double-hurdle and IHS infrequency-of-purchase models. As the two models both accommodate true economic non-consumption and offer plausible explanations for additional causes of zeros in pork consumption, Su and Yen (1996) used a non-nested likelihood-ratio (LR) test procedure to distinguish between the two specifications.

Although the IHS transformation of the double-hurdle model and infrequency-of-purchase models are the two leading LDV models in empirical demand analysis, the existing literature has not provided for convenient incorporation of these models into demand systems. Gao and Spreen (1994) note that a complete system of a double hurdle model is very involved computationally. Literature is rare that presents a full description of this method. An alternative approach to modeling zero consumption in demand systems – Heckman's two step procedure-- is more widely used and is reviewed in the following section.

2.2.3b Sample Selection Bias and Heckman's Two-Stage Procedure

Heckman (1979) provides a two-step procedure with a selection mechanism and a regression model. This method allows the decisions to purchase and the amount purchased to be modeled separately. The 0/1 choice regarding whether or not to purchase is made in the first decision step, and the quantity spent on purchasing the good is then regressed against determinants such as income, price and socioeconomic variables in the second step. An intermediate parameter, the inverse Mills ratio, is calculated from first stage probit choices and then incorporated into the second stage regression model. In this procedure, the selection process is taken into consideration in the consumption process. Heckman's procedure has been widely used to estimate wage rates since an individual's employment status reflects self-selection, thus producing a selected sample of those employed in the labour force (Heckman 1980). The detailed technical aspects of this approach will be discussed in Chapter 3.

2.2.3c Demand Systems Estimation with Selection Bias

Correction of sample selection bias can also be incorporated into demand system estimations with different approaches. Lee (1978) generalized the two-step Amemiya (1974) estimator to a simultaneous-equation model, which consists of observable endogenous variables, unobservable latent endogenous variables with dichotomous indicators, and limited and censored dependent variables, as well as continuous variables. The two stage methods utilize probit analysis in the first stage and a least squares procedure in the second stage. The number of equations is arbitrary. Lee proved that other two-stage estimators— namely, those by Nelson and Olsen (1978) and Heckman (1978)– are special cases of this procedure. Lee's method constructs the basic framework for two-step estimation, and the second step can be easily implemented with different demand systems. This theoretical framework will be further discussed in Chapter 3.

Chiang and Lee (1992) developed a two-step procedure for estimating a random utility model that encompasses the discrete choice of whether or not to consume a particular commodity and the (nonnegatively) constrained quantity consumption decision. In this two-step procedure, a *multivariate* probability distribution incorporates the effect of censoring one commodity on other commodities in the system. Heien and Wessells (1990), Gao and Spreen (1994), and Nayga (1995) in their household-based analyses of food demand use *single-dimension* Heckman-type sample selection correction factors to control for the 0/1-purchase decision. Though attractive because of the ease with which their models can be estimated, correction factors obtained from univariate probit equations do not capture cross-commodity censoring impacts— in fact the non-consumption choice of commodity *i* may simultaneously be affected by the non-consumption choice of commodity *k* within the consumer's budget. For example, a consumer's decisions on whether to purchase FAFH may be correlated with the decisions on FAH expenditure.

In general, the problem of dealing appropriately with zero expenditure is currently one of the most pressing in applied demand analysis. We do not have a theoretically satisfactory and empirically applicable method for modeling zeroes for more than a few commodities at once. However, all household surveys show large fractions of households reporting zero purchases for some goods. Since household surveys typically contain several thousand observations, it is important that procedures developed are also computationally inexpensive.

2.3 Unit Price Adjustment

In early demand analysis studies based on cross-sectional data, prices were usually assumed to be constant, i.e., all households face the same prices (Allen and Bowley 1935, Prais and Houthakker 1952, George and King 1971). Given this assumption, Engel functions are estimated where expenditure (or quantity) is regressed on income (or total expenditures), family size, and other demographic characteristics. Estimation of price elasticities on demand was commonly left to time-series researchers, who obtained price information from inter-temporal indices. More recently, however, there has been renewed interest in the potential of cross-sectional analysis for the estimation of price elasticities on demand for food, especially when surveys collect data on both household expenditures for food items and the physical quantities purchased. The existence of cross-sectional price variation raises several important issues. Polinsky (1977) pointed out that failure to specify cross-sectional price effects adequately could result in biased and misleading demand elasticities. Thus, traditional Engel analysis may be inappropriate if the prices faced by all individual consumers are not equal.

Some researchers (e.g., Timmer and Alderman 1979, Timmer 1981) have simply defined the cross-sectional price as the division of observed expenditure over observed quantity (named "unit value" by Deaton). The price calculated in this way may nevertheless reflect more than spatial variation caused by supply shocks (i.e., transportation costs, cost of information, seasonal variation, etc.). Cross-sectional price data are generally assumed to reflect “quality” effects which should be corrected prior to estimation (Black 1952, Cramer 1973, George and King 1971, Houthakker 1952, Prais and Houthakker 1955, Theil 1952). Based on this view, Deaton (1988) pointed out that it is incorrect to use simple unit values as direct substitutes for true market prices in the analysis of demand patterns. Consumers choose the *quality* of their purchases; hence, calculated prices incorporated in cross-sectional analysis should reflect this choice. Moreover, quality choice may itself reflect the influence of prices as consumers respond to price changes by altering both quantity and quality. Nelson (1991) also argued that the importance of properly adjusting for quality variation depends on the importance of quality effects in the data under examination. For example, rice is a fairly homogenous commodity in Indonesia; hence, Timmer and Alderman (1979)’s treatment of demand for rice using physical quantities and unit value might be theoretically appropriate (abstracting from empirical problems of measurement error).

On the grounds that the quality effect is important in cross-sectional price adjustment and that the unit value obtained by simple division is inappropriate, Cox and Wohlgenant (1986) have developed the most widely used method to adjust price with respect to quality variation based on Theil (1952)'s theoretical framework. Their approach is described below.

As a convention, the term “elementary good” refers to a strictly homogenous good. The term “commodities” refers to heterogeneous goods which vary in their characteristics. A composite commodity such as “beef” will cover a group of elementary goods (or distinct individual purchases, including ground beef, beef steak, stewed beef, etc) that vary in flavor, fat content, freshness, convenience of packaging, etc. Because the purpose of this study is not to estimate price elasticities for every elementary good, some approach must be found to aggregate elementary goods into meaningful composite commodities with corresponding price measures.

The first well-known discussion of the problems created for economic analysis by quality variation was by Houthakker (1952) and Theil (1952) in the early 1950s. The model they created was adapted by Deaton (1986) and Cox and Wohlgenant (1986). Theil (1952) defines heterogeneous commodity quantities as the sum of the physical quantities of elementary goods in the group (assumed to be measured in a common physical unit) and adds "quality" choice as separate set of elements in the household utility function.

This two-step independent modeling of quality and quantity decisions is justified by assuming that a household first decides on the demand for commodity quality through the selection of component goods and then the quantity of the composite commodity. Such decisions are assumed to be based on the income level and other socioeconomic variables of the household. Hence, in order to use commodity prices in demand equation estimation, these must be independent of income and quality effects. To formulate commodity prices, an OLS regression is run[7] in which unit values faced by households are dependent variables and household characteristics and income are explanatory variables (Cox and Wohlgenant 1986). The adjusted prices P_j^* for jth household are assumed to eliminate the "quality" effects induced by household characteristics. For the purchasing household, P_j^* is equal to the intercept $\hat{\alpha}$ plus a residual term $\hat{\varepsilon}_j$ from the regression above:

$$P_j^* = \hat{\alpha} + \hat{\varepsilon}_j \qquad (2.3.1)$$

where quality effects of household characteristics are subtracted from unit values. For non-purchasing households the adjusted price is approximated by the intercept, which is considered as the mean price for all households.

Based on Cox and Wohlgenant (1986)'s approach, there have been some recent developments regarding price adjustment in cross-sectional demand analysis. Dong et al

7 Here the linear form is assumed for the regression because it is the simplest, however, in theory any kind of functional relationship can be applied.

(1998) developed a bivariate model following the approach of Wales and Woodland (1980) and extended the work by Cox and Wohlgenant (1986), to include a two-equation system of expenditure and unit value functions.

Wales and Woodland (1980) note that in the two-equation model, both sample selectivity and simultaneity problems may arise. Sample selectivity arises from the fact that some households may not purchase a commodity. Thus, neither expenditures nor unit values are observed for them. If the unit value is correlated with the disturbance term in the expenditure equation, then simultaneity must be accounted for. Simultaneity is an empirical issue that depends on whether or not the correlation coefficient of the two equations is zero. Its absence still does not ameliorate the selectivity problem. In the Cox and Wohlgenant (1986) approach, the unit value equation is estimated independently from the demand function using only information on purchasing households. This relationship is then used to predict household-specific prices for nonconsuming households.

In Dong et al's method, the issue of whether or not households purchase a commodity is treated jointly with the quality issue because both measures are subject to sample selectivity bias irrespective of any simultaneity. In the empirical part of their paper, they compared the results of Cox and Wohlgenant (1986) to those from the bivariate model and concluded that the bivariate model assessed simultaneity between the expenditures and prices.

2.4 Incorporation of Socio-demographic Variables

In recent food demand studies, various demographic and socioeconomic variables have been embodied into economic models to test their potential effect on expenditure. We can classify the most widely used socioeconomic and demographic variables into the following categories:

Geographic location: province, city, urban or rural area

Class of housing (owned, rented, etc.)

Characteristics of reference person: age, sex, and marital status

Characteristics of spouse: age, sex, and marital status

Educational background

Employment status or labour force participation

Immigration status and ethnic origin

Household composition

Income and total household size

Most of the socioeconomic and demographic variables have readily defined values or choices (continuous or discrete) in the household survey data. Hence, they can easily be incorporate into demand estimation models.

Pollak and Wales (1981) describe and compare general procedures for incorporating demographic variables into any complete demand system without assuming a particular functional form. The widely used procedures include demographic translating and demographic scaling. If a traditional demand system is specified as a function of prices and total expenditure, demographic translating replaces the original constant term of the demand equation with a function of household characteristics. Translating can be interpreted as allowing parameters of a demand system to depend on the demographic variables. Another widely used approach to incorporate household characteristics is demographic scaling. In this procedure, the demand equation and prices are multiplied with a scaling parameter which is a function of demographic variables. Both demographic translating and scaling procedures can be used with the first order condition for the indirect utility function and retain the theoretical specification of demand function. Translating preserves the linearity of the system, whereas scaling is a highly nonlinear specification. Pollak and Wales (1981) suggest that the model estimation results and computed price elasticities are very similar by using either procedure.

While most of the demographic variables (age, gender, etc.) are exogenous, some complicated socioeconomic variables may be considered endogenous. For example, in studies that discuss the influence of a woman's employment status on food-away-from-home or on nutrient intake, the variable for a woman's participation in the labour force is widely considered endogenous. In this case, instrumental variables should be used to model the choice of woman's work status (length of hours, full-time or part-time). These instruments may include country of birth, first language, and age, etc. Incorporating a woman's employment status as an endogenous variable is a typical approach to model socioeconomic variables (Yen 1993). The method can also be used on other socioeconomic variables, if appropriate instruments can be found.

2.5 Collective Models

2.5.1 Unitary and Collective Models

Economic theory attempts to explain the behavior of *individual* 'economic agents' to interpret consumer behavior. The first models of family or household behavior have been termed 'unitary' models. Samuelson (1956) proposed modeling families as if they are maximizing a single 'household utility function' reached by 'consensus' within individual household. The unitary approach to modeling household behavior is also associated with Becker's (1974; 1981) study, in which he argues that 'household preferences' can be modeled as the preferences of the family head who is assumed both to control the bulk of family resources and to act altruistically.

Although the unitary approach has the advantage of simplicity, this simplification has been severely criticized by many economists who believe that ignoring family relations will lead to simpler but less accurate explanations of behavior. They argue that the behavior of the household head is likely to be strongly affected by the preferences or experiences of other family members. The spending decisions may not be "unitarily" made by the household head.

Becker (1974)'s research on unpaid work that goes on within households allowed the results derived for single consumers to be extended to the family situation. The research allowed for the possibility of influences of one spouse upon the behavior of the other. Many authors who have used the unitary approach (Hausman and Ruud 1984, Kooreman and Kapteyn 1987, Phipps 1990) have also recognized that individual decisions can depend in important ways upon the experience of the spouse. This has resulted in the development of collective models.

Collective models of household behavior assume that individuals within households have distinct preferences. These models also incorporate the idea that control of market income may influence decision-making power within the household and hence observable behavior (such as expenditure patterns or labour supply). Much of the empirical research in this area has attempted to determine whether or not income sources affect behavioral outcomes (See Phipps and Burton 1995 for a survey).

2.5.2 Empirical Studies on Within-Household Inequality with Microdata

Browning and Meghir (1991) examined the effects of male and female labour supply on household demands and presented a simple and robust test for the separability of commodity demands from labour supply. Using data on individual households from six years of the UK FES, they examined a demand system for seven goods which includes hours and participation dummies as conditioning variables. Labour supply is treated as a conditioning good and the research sample is concentrated on households consisting of one married couple with or without children. A general conditional demand system is developed where working hours of husbands and wives are incorporated as separate explanatory variables. Demand functions for the husband and wife are not estimated separately but the effect of male and female labour supply on demand is investigated through the respective model coefficients. They found that ignoring the effects of labour supply leads to bias in the parameter estimates which generate larger elasticities than the models considering participation.

Browning et al (1994) investigated the intra-household allocation model by using Canadian family expenditure survey data. They explicitly assumed the existence of a sharing rule within household allocation and a parametric model was developed based on this sharing rule. Based on the sharing rule, the expenditures of husband and wife are separated and individual demand functions for each spouse are estimated. Effects of individual income on individual demand are investigated through the separate demand functions for each member of the household. The difference between Browning and Meghir (1991) and Browning et al (1994) is that the later study explicitly defined the sharing rule which made the estimation of individual demand functions within household possible. Browning et al (1994) found that expenditures on the wife's share of private non-durable consumption increases with an increase in her share of income or her age relative to that of her spouse. These findings reinforce the point of Pahl (1983) that wives with higher earnings have more control over how their earnings are spent. Evidence from these results is that the relative incomes of husband and wife affect the pattern of consumption within families in ways which will alter the distribution of well-being.

Woolley and Marshall (1994) used a Canadian data set (The Winnipeg Area Study) on household financial management. They compare standard measures of household income inequality, which assume individuals within the household are equally well-off, with measures which use responses to a financial management questionnaire to adjust for differential control of resources coming into the family. Adjusting for inequality in control of resources yields a Gini coefficient that is 27 per cent higher than that calculated in the usual fashion with household income, which indicates that the intra -household allocations of income is not equal among family members.

Phipps and Burton (1995), using microdata from the Luxembourg Income Study, find that social institutions can play an important role in influencing behavior, as suggested by collective bargaining models and by Pahl (1983). For example, higher social transfers to *single* women and higher average levels of child support are associated with higher levels of labour-force participation for *married* women, a finding which could be consistent with a 'divorce-threat' bargaining model. The increase in welfare in the event of a separation would increase bargaining power and consequently the welfare of women during marriage.

In summing up this empirical research on the distribution of welfare within families using micro-data, we found that there was very little literature which discusses intra-household allocation of food demand. Only Browning and Meghir (1991) include 'all' food as a group in their study. Their estimated expenditure and own price elasticities for food are 0.47 and -0.10. Their results indicate that ignoring labour supply issues may generate biased estimates and higher elasticities. Based on our particular data restrictions that no income information for individual household member is available[8], we will tentatively incorporate a sub-sample approach to micro-level food demand analysis and

8 In this case the collective model based on the "sharing rule" proposed by Browning et al (1991) cannot be estimated due to the lack of individual income information in household.

investigate the differences between sub-samples using the Chow (1960) tests. The theoretical framework of the Chow (1960) test will be discussed in section 3.6 and details of the application are introduced in Chapter 5.

Chapter 3 Theoretical and Empirical Frameworks

The common approach to demand analysis is the assumption of utility maximization by consumers. This framework can be extended to household production theory, which is particularly appropriate to this study of household food expenditure. In this chapter household production theory is interpreted. Food demand functions incorporating socioeconomic and demographic variables are derived from this. A single equation expenditure function and an Almost Ideal Demand System (AIDS model) are postulated as two estimation models. Sample selection bias from zero expenditure is corrected with Heckman's procedure. Due to the limitation of FFES data, (separate income information for different household members is not available), we can only test the collective behavior of household members by applying sub-sample estimations and comparisons without changing the model setting. Hence, the model specifications in this chapter are primarily based on the unitary approach, with some discussions on the sub-sample method.

3.1 Household Production Theory

Household production theory has been proposed and enriched by Becker (1965), Lancaster (1966), and Gorman (1980). The theory encompasses the theoretical basis of food demand estimation and this is developed as a typical utility maximization problem. A household is regarded as both a production and consumption unit considering the opportunity costs of time spent on non-wage-earning work. The approach considers the process of transforming purchased food and other market goods and time allocated to particular non-market activities into household produced goods, such as a dinner cooked at home and ready to serve. The household is considered maximizing the indirect utility function by household production of non-market goods and direct consumption of market goods. Mathematically the basic household production model can be written as:

$$\underset{\{x_{ij}, t_i, t_w\}}{Max}\ U = U(C_1, \ldots C_i(x_{ij}, t_i) \ldots, C_n, \chi, \Psi) \qquad (3.1.1)$$

where U is the indirect utility function of household; C_i (x_{ij}, t_i) [9] are short-run cost functions of producing the ith non-market good (such as a ready-to-eat meal cooked at home); x_{ij} is a vector of the quantity of the jth market good (such as an ingredient or component) used in household production for non-market good i; [10] χ is a vector of other market goods directly consumed (not used for household production); Ψ is a vector of socioeconomic variables for members of a household; t_i is the time allocated to the household production of ith non-market good; and t_w is the time allocated to working in a market job. The maximization of the household utility function is subject to three constraints:

1. Production/Cost Constraints: $C_i = f(x_{ij}, t_i)$ for $i = 1,...m, j = 1,...,n$ (3.1.2)

where the short-run cost for producing a non-market good is a function of inputted market goods and the input of time allocation, i is the number related to non-market goods, j is the number related to market inputs, m, n is the maximum possible number of i and j, and $m<n$.

2. Budget Constraints: $\sum_1^n p_j x_j \leq A + t_w w = M$ (3.1.3)

where p_j is a vector of prices for j market goods; A is non-wage income; t_w is the time allocated to working in a wage-based job; w is the wage rate; M is total household income. The household budget that is available to be spent on all purchased market goods is equal to the total household income, which is the summation of employment income ($t_w w$) and other income (A). To simplify the analysis, savings are not considered.

3. Time Constraints: $t_w + t_c \leq t$ where $t_c = \sum_1^n t_i$ (3.1.4)

where t is total time endowment; t_w is the time allocated to wage-based work; t_c is total time allocated to household production; t_i is time allocated to the production of each non-market good i. Again, time endowment is also simplified without considering leisure.

9 Deaton and Muellbauer (1986) use z to denote non-market good, and the indirect utility function is simplified as u=v(z), we use C to denote the cost to produce z and embodied it directly in the utility function.

10 In this chapter, market good inputs are denoted as x in lower case, total expenditure is denoted as X in upper case, and the vector of independent variables is denoted **x** in bold.

The household production of non-market goods is assumed to be determined through the maximization of utility function (3.1.1). Households are considered to allocate their time and market goods as inputs to achieve production activities that maximize household utilities. The demand functions for various market goods x_{ij} can be derived from the utility function as discussed in section 3.2.

The original specification of household production theory can be modified in the context of this food demand study by specifying the purchased items in all categories that reflect their nature. The utility maximization function for a household that makes ready-to-eat meals using different food categories can be expressed as:

$$\underset{\{x,\, t_i,\, t_w\}}{Max}\; U = U(C_i(x_1, x_2, \ldots, x_{fafh},\; x_{fah}, x_{cov}, x_{meal}, x_{snk}, \ldots, x_j, t_i),\; C_{others}(x_{ij}, t_i \chi;\; \Psi) \qquad (3.1.5)$$

where C_i are cost functions of producing the ready-to-eat meals for a household (which are non-market goods); x_{fafh} is a vector of various foods-away-from-home items specified by type of selling facility and food; x_{fah} is a vector of raw food items that require cooking prior to being consumed at home; x_{cov} is a vector of convenience foods that receive final cooking before being consumed at home; x_{meal} is a vector of prepared meals that are heated and consumed at home; x_{snk} is a vector of different snacks served and consumed at home; and all x's are market goods inputted in household production. C_{others} is a vector of all other household produced non-market goods besides C_i; χ is a vector of other market good directly consumed; Ψ is a vector of socioeconomic variables specific to household members. As previously outlined, utility maximization is assumed subject to the budget constraints (3.1.3), time constraints (3.1.4), and modified Production/Cost Constraints (3.1.6):

$$C_i = f(x_1, x_2, \ldots, x_{fafh}, x_{fah}, x_{cov}, x_{meal}, x_{snk}, \ldots, x_j, t_i) \qquad \text{for } i, j = 1, \ldots, n \qquad (3.1.6)$$

where the cost to produce ready to eat non-market meals in a household (C_i) is based on the quantity of purchased food items ($x_{fafh}, \ldots, x_{snk}$) , other inputted market goods, and the time constraint.

3.2 Derived Demand for Food Purchases

The utility function of the household depends on the household cost function for producing non-market goods with respect to three sets of constraints. The input demand for these market goods can be derived by taking the derivatives of C with respect to the input price p_j (Shepard's lemma approach). For the production/cost function constraint in the context of this food demand study, particular market commodities of interest are specified: x_{fafh}, x_{fah}, x_{cov}, x_{meal}, and x_{snk}. By apply Shepard's lemma, we obtain the input demands for these major food items as the following:

- demand for food-away-from home items

$$x_{fafh} = D(p, w, A, \Psi) \tag{3.1.7}$$

- demand for food-at home items

$$x_{fah} = D(p, w, A, \Psi) \tag{3.1.8}$$

- demand for convenience food

$$x_{cov} = D(p, w, A, \Psi) \tag{3.1.9}$$

- demand for prepared meals

$$x_{meal} = D(p, w, A, \Psi) \tag{3.1.10}$$

-demand for snacks

$$x_{snk} = D(p, w, A, \Psi) \tag{3.1.11}$$

where D is any form of demand functions.

When the quantities demanded are multiplied by prices/opportunity costs, we can obtain expenditure equations[11]. The demand functions can also be viewed in a demand system context such as in a form of expenditure share. The demand equation includes a set of variables Ψ, which reflect specific socioeconomic-demographic characteristics of the household such as age, gender, education, household composition, and race of household members. Normally the information of w and A is contained in the M (income) in survey data, and instrument variables are needed to correct for the endogenous problem when M is used in estimation.

11 Engel equations.

A particular functional form for food demand equations (equation 3.1.7-3.1.11) is required. For the single equation function, Engel equations that are commonly reported in the literature (e.g., Deaton 1986) can be generalized as

$$E_i = a_i(\Psi) + \varphi_0^i(p,\Psi) + \sum_{j=1}^{J} \varphi_j^i(p,\Psi) b_j(M,\Psi) \tag{3.2.7}$$

where E_i denotes expenditures on the *i*th food category;

a_i is the intercept of the Engle equation;

$\varphi_j^i(p,\Psi)$ are homogeneous of degree zero functions of prices;

$b_j(M,\Psi)$ are polynomials with expenditure/income as arguments; and

Ψ is a vector of socioeconomic variables.

Engle equations with expenditure as the left-hand-side variable are postulated as particular single equation functional forms applied in this study.

3.3 Complete AIDS Model With Socioeconomic & Demographic Variables

The Almost Ideal Demand System (the AIDS Model) developed by Deaton and Muellbauer (1980) is adopted in this study for demand system estimation. It makes an arbitrary first-order approximation to any demand system and it is derived using the concepts of duality. Socioeconomic and demographic variables are incorporated into the AIDS model using the demographic translating procedure proposed by Pollak and Wales (1978, 1981). The cost function of various food consumption bundles is specified as

$$C(p,u) = a(p)^{(1-u)} * b(p)^u \text{ [12]} \tag{3.3.1}$$

or in logarithmic form

$$\ln C(p,u) = (1-u)\ln a(p) + u \ln b(p) \text{ [13]} \tag{3.3.2}$$

where this particular specification is called *price independent generalized logarithmic* (PIGLOG), where $a(p)$ and $b(p)$ are functions of prices, and u is the indirect utility function.

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12 Because $C(p,u)$ is an expenditure function, it is homogenous of degree 1 in prices, requiring $a(p)$ and $b(p)$ to be homogeneous of degree one, too.

13 The indirect utility function can be obtained immediately from the expenditure function by simple inversion $u(p,C) = \ln(c/a(p))/\ln(b(p)/\ln a(p))$ (Deaton and Muellbauer 1980).

The PIGLOG expenditure function can be specified as:

$$\log c(u,p) = \alpha_0 + \sum_i \alpha_i \log(p_i) + \frac{1}{2}\sum_i\sum_j \gamma^*_{ij} \log(p_i)\log(p_j) + u\beta_0 \prod_i p_i^{\beta_i} \qquad (3.3.3)$$

where p_i represents the price of commodity i. From equation (3.3.3) , we can directly use Shepard's lemma to derive the demand functions, where the budget share is a function of price and utility:

$$S_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i u \beta_0 \prod p_k^{\beta_k} \qquad (3.3.4)$$

where S_i is the expenditure share of ith food category;

$$\gamma_{ij}^* = \frac{1}{2}(\gamma_{ij}^* + \gamma_{ji}^*) \qquad (3.3.5)$$

For a utility-maximizing consumer, total expenditure X is equal to $c(u,p)$, and this equality can be inverted to give u as a function of p and X, the indirect utility function. If this is done for (3.3.3) and the result is substituted into (3.3.4), we have budget shares as functions of p and X, which express as the AIDS model in budget share form (3.3.6). The equation for the budget share of the i^{th} commodity can be specified as:

$$S_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left[\frac{X}{P^*}\right] \qquad (3.3.6)$$

where S_i, is the budget share of ith commodity, P_i is the price for ith commodity, X is the total expenditure of the household, and P^* is a price index defined by

$$\log P^* = \alpha_0 + \sum_k \alpha_k \log P_k + \frac{1}{2}\sum_j\sum_k \gamma_{k,j} \log P_k \log P_j \qquad (3.3.7)$$

Adding up restrictions requires that $\sum \alpha_i = 1, \sum \gamma_{ij} = 0, and \sum \beta_i = 0.$ Homogeneity requires $\sum \gamma_{ij} = 0$, and symmetry requires that $\gamma_{ij} = \gamma_{ji}$.

In many practical situations, where prices are relatively collinear, P_t will thus be approximately proportional to any appropriately defined price index, for example, that used by Stone, the logarithm of which is given by $\Sigma w_k \log p_k$. Such an index can be calculated before estimation so that (3.3.6) becomes straightforward to estimate. Replacing the price index (3.3.7) with Stone's price index gives the linear approximation of the AIDS model (LAIDS), which is extensively used in the demand analysis and also applied in this study.

To introduce the effects of socio-economic and demographic variables into the demand system, the coefficients a_i in (3.3.7) are modified following the conventional demographic translating approach specified by Pollak and Wales (1978,1981):

$$a_i(\Psi_k) = l_0 + \sum_{k=1}^{K} l_k \Psi_k \qquad \text{such that} \qquad \Psi_k = \{\Psi_1, ..., \Psi_k\}. \tag{3.3.8}$$

where Ψ_k is the kth socioeconomic and demographic variable, l_0 is the adjusted intercept and l_k is the coefficient for the socioeconomic variable.

To maintain the adding-up and homogeneity restrictions, the coefficients in (3.3.8) are restricted in the following way:

$$\sum l_0 = 1 \text{ and } \sum l_k = 0$$

In the context of our food demand study, the complete (linear) demand system with socioeconomic and demographic effects is written as:

$$S_i = l_0 + \sum_{k=1}^{K} l_k \Psi_k + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln(\frac{X}{P^*}) + \epsilon_i, \quad i=1,\ldots,n \tag{3.3.9}$$

where n is the number of goods, and ϵ_i is the error term.

3.4 Correction for Sample Selection Bias

As mentioned in Chapter 2, the zero expenditure data problem causes bias when using traditional estimation methods. Frequently, the ordinary least square (OLS) approach has been used for single equation demand function estimations. The standard estimation method for demand systems (i.e. seeming unrelated regression estimation, SURE) also produces biased estimates when zero purchases of some goods are reported. The bias stems from the fact that the distributions of dependent variables are conditional on a sample selection rule where error terms have a non-zero mean. The sample selection problem can be solved by applying Heckman's (1978) procedure to single equation estimation or the extension for systems of equations developed by Lee (1978).

3.4.1 Heckman's Two-stage Method for Single Equation Estimation

The Heckman two-stage method is a convenient estimation procedure for correcting sample selection bias. Following Heckman (1978), the single equation sample selection model is described as follows:

The first stage is the *Selection Mechanism* for obtaining the probability of participation (whether or not to purchase):

$$z_i^* = \gamma'\Psi_i + \mu_i \qquad (3.4.1)$$

$$z_i = 1 \quad \text{if } z_i^* > 0,$$

$$z_i = 0 \quad \text{if } z_i^* < 0,$$

Probability ($z_i=1$) = $\Phi(\gamma'\Psi_i)$

Probability ($z_i=0$) = $1-\Phi(\gamma'\Psi_i)$

where z_i is the latent variable for 0/1 purchase (participation) choices; Ψ_i is the vector of socioeconomic and demographic variables; γ is a coefficient vector; μ_i is the random error term of (3.4.1); and Φ is the standard normal cumulative distribution function.

The second stage is the *Regression Model* for participating (purchasing) households:

$$y_i = \beta \mathbf{x}_i + \epsilon_i, \quad \text{observed only if } z_i=1, \qquad (3.4.2)$$

$$(\mu_i, \epsilon_i) \sim \text{bivariate normal distribution.}$$

Precisely, $E[y_i \mid z_i = 1] = \beta \mathbf{x} + \rho\sigma_\epsilon \lambda(\gamma'\Psi)$ and $\lambda(\gamma'\Psi) = \dfrac{\phi(\gamma'\Psi_i)}{\Phi(\gamma'\Psi_i)}$

where y_i is the actual demand that is specified either in quantities or in expenditures; $\mathbf{x}$ is the vector of demand determinants, including income, price and socioeconomic variables; and β is a vector of coefficients. The term $\lambda(\gamma'\Psi)$ is called the inverse Mills ratio; ϵ_i is the random error term of (3.4.2); σ_ϵ is the standard deviation of the marginal distribution of ϵ_i, and ρ is the correlation coefficient between μ and ϵ. The means of μ and ϵ are assumed to be 0, 0 and the standard deviations are assumed to be 1, σ_ϵ, respectively. For a detailed distribution of bivariate and incidental truncation distribution, see Greene(1997).

The parameters of the sample selection model can be estimated by maximum likelihood methods. However, this is quite cumbersome, and an alternative procedure, following Heckman (1978), is usually used instead. The estimation procedure of Heckman' s two-step approach is specified as follows:

(1). Estimate the probit equation by maximum likelihood to obtain estimates of γ. For each observation in the selected sample, compute $\hat{\lambda}_i = \phi(\hat{\gamma}\Psi)/\Phi(\hat{\gamma}\Psi)$ and $\hat{\delta}_i = \hat{\lambda}_i(\hat{\lambda}_i + \hat{\gamma}\Psi_i)$.

(2). Estimate β and $\beta_\lambda = \rho\sigma_\epsilon$ by least squares regression of y on $\mathbf{x}$ and $\hat{\lambda}$.

In this computational framework, selection bias corrections are made for a single equation demand function by first implementing a probit estimation to obtain the inverse Mills ratio λ, and then embodying this into a regression model with the two stage least square regression technique. Heckman' s estimation procedure can be undertaken with the computation package in Limdep™ 7.0(*Econometric Software Inc*, 1998, 1999).

3.4.2 Incorporating Heckman' s Procedure into Estimation of Demand System

Theoretically, Heckman's two-stage method can also be embodied into the estimation of any demand system (Heien et al. 1990). Again, the estimation procedure involves two steps. First, a probit regression is computed to determine the probability that a given household will consume the goods in question. This probit regression is then used to compute the inverse Mills ratio for each household. Next the calculated inverse Mills ratio is employed as an instrument that incorporates the censoring latent variables in the second stage estimation of the demand relations. For the system demand estimation, the inverse Mills ratio will be introduced into each equation of the system. In this way, we can incorporate the inverse Mills ratio into any complete demand system (Heien et al. 1990).

As mentioned in Chapter 2, although *single-dimension* Probit sample selection correction factors are widely used to control the 0/1 purchase decision for system estimations, due to the ease of the estimation procedure, correction factors obtained from univariate probit equations do not capture cross-commodity censoring impacts (Chiang and Lee 1992) . We attempted to use the multivariate probit model in the first stage estimation, however, the data set is conflict with the model and this approach was not fulfilled. Hence, the conventional univariate probit estimation is still applied in this study. The estimation procedure of demand system with selection is specified as following:

First, a univariate probit model is estimated for all commodities included in the demand system equations, and inverse Mills ratios are calculated. The inverse mills ratios are:

$$\hat{\lambda}_i = \frac{\phi(\hat{\gamma}_i{}' \Psi_i)}{\Phi(\hat{\gamma}_i{}' \Psi_i)} \text{ if expenditure occurred,} \tag{3.4.3-1}$$

$$\hat{\lambda}_i = \frac{\phi(\hat{\gamma}_i{}' \Psi_i)}{1-\Phi(\hat{\gamma}_i{}' \Psi_i)} \text{ if expenditure is zero} \tag{3.4.3-2}$$

where $\hat{\gamma}_i{}' \Psi_i$ is the model used for the probit regression; $\phi(\cdot)$ is the standard normal probability density function; and $\Phi(\cdot)$ is the standard normal cumulative distribution (Heien et al. 1990 and Greene 1997).

In the second step, the demand system with the inverse Mills ratio (3.4.3) included is estimated using Maximum Likelihood (ML) methods. The equation of (3.3.9) is then revised as:

$$S_i = l_0 + \sum_{k=1}^{K} l_k \Psi_k + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln(\frac{X}{P^*}) + \beta_\lambda \hat{\lambda} + \epsilon_i \tag{3.4.4}$$

where β_λ is the estimated coefficients of the inverse mill ratio.

To estimate n demand equations simultaneously, only n-1 demand equations can be included in the system because the n equations shares add up to 1 and inclusion of all n demand equations results in a singular variance-covariance matrix for ML estimation. Any equation of the system can be dropped (Barten 1969). However, it is conventional to drop the smallest share, and we follow this procedure.

3.5 Calculation of Elasticities

The computation of marginal effects and elasticities after correcting for sample selection bias and considering the inverse Mills ratios is presented in Saha et al (1997). The overall marginal effects with respect to expenditures for single equation demand function and demand system are specified as:

$$\text{ME}_{kj} = \hat{\beta}_j - \hat{\beta}_\lambda \hat{\gamma}_j \left[(\Psi_k \hat{\gamma})\bar{\hat{\lambda}} + \bar{\hat{\lambda}}^2 \right] \tag{3.5.1}$$

for single equation demand function; and

$$\mathrm{ME}_{kj} = \hat{\beta}_{ij} - \hat{\beta}_{\lambda i}\hat{\gamma}_{ij}\left[\theta_i\left(\Psi_k\hat{\gamma}_i\hat{\lambda}_{ij}^{-A} + (\hat{\lambda}_{ij}^{-A})^2\right) + (1-\theta_i)\left(\Psi_k\hat{\gamma}_i\hat{\lambda}_{ij}^{-B}\right) - (\hat{\lambda}_{ij}^{-B})^2\right] \quad (3.5.2)$$

for demand systems, where

$\lambda^{-A}=\phi(\Psi_k\gamma_i)/\Phi(\Psi_k\gamma_i)$ for nonconsuming household, and

$\lambda^{-B}=\phi(\Psi_k\gamma_i)/1-\Phi(\Psi_k\gamma_i)$ for consuming household.

Here Φ and ϕ are the normal cumulative distribution and the probability density functions; λ is the inverse Mills ratio; and β_λ is the estimated coefficient of the inverse Mills ratio obtained from the second stage demand system estimation. β is the estimated coefficient for second stage selection regressions, γ is the estimated parameter in the first stage probit estimation , and θ is the proportion of observations for which consumption choice Z=1. Ψ is the socioeconomic variable vectors of the first stage probit estimation. The computation of marginal effect combined direct effects from demand determinants (the first term of equations 3.5.1 and 3.5.2) and indirect effects from the first stage selection process (the second term of equations 3.5.1 and 3.5.2).

The uncompensated price elasticities for the single equation demand function with expenditure as the dependent variables are derived in this study as follows:

$$\varepsilon_{ij} = ME_{lnp\,ij}/E_i - \xi = ME_{p\,ij}/q_i - \xi \qquad \xi=1 \text{ for } i=j \text{ and } \xi=0 \text{ for } i\neq j \quad (3.5.3)$$

where E_i, p_i and q_i are the expenditure, price and quantity for the ith food category, and ME_{lnp} and ME_p are the marginal effects of log and linear prices on food expenditure with inverse Mills ratio incorporated. Regardless of whether original or log prices are used, the price elasticities can be derived from both forms and they are mathematically equivalent. The detailed procedure of elasticity calculation and equivalence in quantity and expenditure forms are provided in Appendix 1.

Following Saha et al (1997), the elasticities of demand (expenditure) with respect to the socioeconomic variables for the single equation demand function can be derived as follows:

$$\eta_{ik} = \frac{\partial E_i}{\partial \Psi_{ik}}\cdot\frac{\Psi_k}{E_i} = ME_{\Psi ik}\cdot\frac{\Psi_k}{E_i} = (\beta_k + \beta_\lambda * \frac{\partial \hat{\lambda}}{\partial \Psi_k}) * \frac{\Psi_k}{E_i} \quad (3.5.4)$$

For demand system estimation, if we use expenditure share S_i as the dependent variable, there will be some modifications in the expression for elasticities. From Green and Alston (1990) and Saha et al (1997), the price elasticity corresponding to the linear AIDS model (LAIDS) is derived as:

$$\varepsilon_{ij} = -\xi_{ij} + \frac{\gamma_{ij}}{S_i} - \beta_i \frac{S_j}{S_i} + \frac{\beta_{\hat{\lambda}}}{S_i} \cdot \frac{\partial \hat{\lambda}_i}{\partial \ln p_j}, \tag{3.5.5}$$

where $\xi_{ij} = 1$ if $i=j$ and 0 otherwise, and $\hat{\lambda}$ is the inverse mills ratio.

The elasticities for all socioeconomic variables and the elasticity for total expenditure from demand system are specified in (3.5.6) and (3.5.7):

$$\eta_{\Psi_k} = \{\frac{l_k}{S_i} + \frac{\beta_{\hat{\lambda}}}{S_i} \cdot \frac{\partial \hat{\lambda}_i}{\partial \Psi_k} + \frac{\partial \ln X}{\partial \Psi_k}\}.\overline{\Psi}_k \tag{3.5.6}$$

$$\eta_{\exp_i} = 1 + \frac{\beta_i}{S_i} + \frac{\beta_{\hat{\lambda}}}{S_i} \frac{\partial \hat{\lambda}_i}{\partial \ln X} \tag{3.5.7}$$

where l_k is the estimated coefficients of kth socioeconomic characteristic for a household. The calculations of all above elasticities can be implemented with Limdep™ 7.0(*Econometric Software Inc*, 1998, 1999).

3.6 Test of Structural Change and Sub-sample Grouping

In order to investigate the collective behavior of intra-household allocations on food expenditure decisions, a collective model of food demand should be estimated. Because we do not have the income information on individual household members based on the FFES data, the standard collective models cannot be estimated. An alternative approach to investigate the effects of individual household members on household decisions for food expenditure may be based on a comparison of different sub-samples of the data, with respect to the characteristics of particular household members. For example, estimated coefficients from a sub-sample of single person households may be different from sub-sample estimates of married-couple households. This suggests that decisions on purchase may be made "collectively" by both members of the married couple household rather than the household head. By testing the hypothesis that estimated coefficients from different sub-samples are not identical and comparing the price and income elasticities from various sub-samples, the postulated intra-household allocation on food expenditure decisions between each sub-sample may be investigated.

To test the hypothesis that coefficients from subsets of the data are identical, a Chow (1960) test can be implemented after we obtain the regression results from different sub-samples. The test procedure is developed by Chow (1960) and is widely used to investigate structural changes using time-series data. The Chow test is represented by the following formula:

$$F=\{[csse-(sse1+sse2)]/k\} / [(sse1+sse2)/(n1+n2-2K)] \quad (3.6.1)$$

where F is the Chow test statistics; *sse1* is the sum of squared errors for the regression using the sub-sample a; *sse2* is the sum of squared errors for the regression using the sub-sample b, *csse* is the sum of squared errors for the combined regression (by pooling sample a and b), K is the number of parameters, $n1$ is the number of observations in sub-sample a, and $n2$ is the number of observations in sub-sample b. The Chow test statistics follow the F distribution, with the degrees of freedom equal to n_1+n_2-2K. The Chow test is used in this study to investigate the sub-sample grouping with respect to different household members, as well as the structural changes between 1986 and 1992.

Chapter 4 The Data

4.1 Coverage and Survey Method

Statistics Canada has carried out fifteen food expenditure surveys since 1953. The coverage for most of these surveys has been restricted to selected cities. Only five of the food expenditure surveys have included smaller urban and rural areas to provide national coverage—1969, 1982, 1986, 1992 and 1996. The primary reason and budgetary justification for collecting expenditure data is to monitor and periodically update the weights used in the computation of the Consumer Price Index (CPI). In addition, food expenditure data classified by covariates such as income, household type, province, etc., provide the basis for a variety of analytical investigations of the food purchasing habits of households in Canada which can be used for market analysis and nutritional studies.

The samples for the 1986 and 1992 surveys were selected by Statistics Canada from the Labour Force Survey sampling frame[14]. The samples were drawn for the whole year and then divided into monthly sub-samples to evenly distribute data collection over the entire calendar year. The selection of the sample consisted of two main steps: the selection of clusters from predetermined Labour Force Survey rotation groups within each area and the selection of dwellings with these selected clusters. The design for the Food Expenditure Survey was a stratified multi-stage sampling scheme. The sampling errors for such a design are usually higher than those for a simple random sample of the same sample size. However, Statistics Canada felt that the operational advantages for this scheme outweighed the disadvantage, and the fact that the sample is stratified also improves the precision of estimates (Statistics Canada 1992, 1996).[15]

The 1986 and 1992 surveys were designed to provide information for persons living in private households in the 10 provinces of Canada as well as Whitehorse and Yellowknife. However, the records from Whitehorse and Yellowknife were excluded from both the 1986 and 1992 public files. The survey was conducted over the period of

14 A detailed description of the Labour Force Survey sampling frame can be found in *Methodology of the Canadian Labour Force Survey*, Statistics Canada; Catalogue No. 71-526.

15 Measurement of sampling error can be found in Statistic Canada- Catalogue No. 62-554-XPB.

one year within different areas. Hence, each record in the FFES data set is identified by the time (in which quarter and week, the expenditure diary applies) and location (province, city, etc.) For each household, the survey was completed in two survey weeks, and this data set is considered as two-week cross-sectional micro-data. As the two survey weeks were completed separately, we aggregated the two-week data for further estimation.

4.2 Structure

The FFES data consist of two files. One summary file contains the data on demographic and socioeconomic variables, food-away-from-home information, and aggregated data concerning detailed food-at-home expenditures. As well as the information in the summary file, information is given in a detailed item file which records all detailed food items purchased and consumed at home (i.e., all expenditures and quantities). The purchase of an item by a household in a week in one type of store constitutes one record. If a household made no purchases of an item, no record will be present for that item, which represents the zero expenditure problem described earlier.

The summary file arranges the socioeconomic and demographic variables into several general categories. These include:

1) The identification and location of the household

The location variables identify the household's geographic location and the time of the survey. Variables under this category are: identification number, week, quarter, province, size of area of residence and city indicator.

2) Housing status

Two variables are in this category: They identify the household's housing status by type of housing (apartment or house) and the class of tenure (own or rent).

3) Characteristics of reference person

This category identifies the characteristics of the household head, by providing the following variables: marital status, age, sex, educational level, occupation, employment status, mother tongue, immigrant arrival year, and country of birth.

4) Characteristics of spouse

This category identifies the characteristics of the spouse of the household manager. All variable classifications are same as in category 3.

5) Household description

This category identifies the household composition, size, number of people and detailed income information for the household. The names of the variables are listed in Appendix 6.

As well as socioeconomic and demographic variables, the summary files also classify the food-away-from-home variables and summary information for detailed food-at-home expenditures. We will describe these variables later in this chapter.

The basic structure of the 1986 and 1992 data sets are similar. However, there are a few differences in the two data sets. In the summary file of the 1992 data, group categories of food-at-home are not listed as in the 1986 data. In the 1986 data there is double presentation since this is also given in the detailed files. In the 1992 data, the definitions of some variables have been modified to provide more accurate information on recent developments. For example, a choice of "Asian Pacific region" has been added to the country of birth variable to reflect the increasing number of immigrants coming from this region.

4.3 Classification of Food Categories

To obtain information on household expenditures and quantities of food purchased in the five categories of food consumption specified in this study, the data files require manipulation through the following steps:

First, it is necessary to identify and aggregate the various foods items in each main food category for each household to obtain the gross expenditure of the five categories. For each detailed food item, the FFES data assign this an item code that can be easily recognized by any database software. This item code is the key variable we use in identifying and aggregating.

Second, after obtaining the gross quantity and expenditure for the five categories for each household, we need to connect this newly generated data sample with the summary files of socioeconomic and demographic variables. The bridge for these two files is the key variable-identification number of each household in both files. Through the fulfillment the above two steps, a newly created data file with both demographic variables and aggregated food consumption information on five main categories is developed for further estimation purposes.

The classification of convenience foods, prepared meals, snacks and food at home in this study has followed the method of Park and Capps (1997). Each of 250 FFES food categories is categorized based on its degree of preparedness. One main difference between the classification of Park and Capps (1997) and this study is the treatment of infant food[16]. Because infant foods are ready to eat, we include them as convenience food items. The classification process resulted in 30 FFES food codes classified in the "convenience foods", four FFES food codes classified in the "prepared meals", 49 FFES food codes classified in the "snacks" and others categorized as food-at-home. The categorizing of food-away-from-home follows the original classification of FFES data in which five major types of FAFH are recorded. Detailed classifications for all five food categories are presented in Appendix 2.

4.4 Summary Statistics

4.4.1 Expenditures for Five Categories

The average expenditures for the five major food categories for 1986 and 1992 are presented in Table 4.4.1.

Table 4.4.1 General Statistics of Food Expenditure from FFES Data *

Expenditure	*1986 Mean*	*1992 Mean*	*Gross Growth Rate*	*Real Growth Rate* †
Total food expenditure	179.81	213.10	18.5%	-7.03%
1.Food-away-from-home	47.96	61.69	1.286%	1.01%
2.Food at home	76.59	75.45	-1.4%	-22.7%
3.Convenience food	24.96	30.55	22.4%	-3.99%
4.Prepared meal	0.99	1.20	21.2%	-4.91%
5.Snacks	27.14	41.80	54.0%	20.82%
Subtotal of 2-5	129.68	149.00	48.9%	-9.87%

† The real growth rate is calculated based on a 86-92 gross inflation rate at 27.48%. (Purchase power of 100 real dollars in 1986 is equal to 127.48 current dollars in 1992, Sources: Statistics Canada, Consumer Price Indexes for Canada, monthly, 1914-1999, 1996 class (CANSIM series number: p10000).

16 Infant food was not included in the Park and Capps (1997) study.

* Two-week data, means of expenditures are current dollars.

Table 4.4.1 describes the changes in food expenditures over the six-year period. The gross growth rate indicates that food expenditure in most categories increased between 1986 to 1992, with the only exception being food-at-home. However, after the current dollars of 1992 are deflated, we found that only FAFH and snack expenditures increased. While expenditure on snacks has the largest growth rate (20.82%), the FAH expenditure decreased by 22.7%. The substantial increase in expenditure on snacks may indicate an increasing attention on healthier foods, such as fruit and yogurt. The subtotal of food-at-home, convenience food and prepared meals indicates that expenditure on all food consumed at home decreased by 9.87%. The increase in away-from-home and decrease in at-home expenditures suggest households have tended to spend more on FAFH but less on traditional food at home. This may reflect an influence of a more fast-paced lifestyle. The average total food expenditures in terms of real dollars of 1986 have decreased by 7.03%. Because the six-year period from 1986 to 1992 was a booming-recession business cycle in the Canadian economy[17], the changing macroeconomic environment may have negatively affected the total food expenditure in terms of quality. During a recession, the quantity of food purchased may not change, but items chosen may change to cheaper, low quality products due to a presumed decrease in the living standard. However, the gross growth numbers in Table 4.4.1 may not properly reflect the changes in expenditure shares of different food categories. A further description of each food category in share form is presented in Figures 1 and 2.

17 The economic growth started from 1986, reached a crest in 1989, and fell to the bottom again in 1992. Sources: Statistic Canada (1996)

Figure 1 Proportions of Food Expenditures according to FFES data, 1986

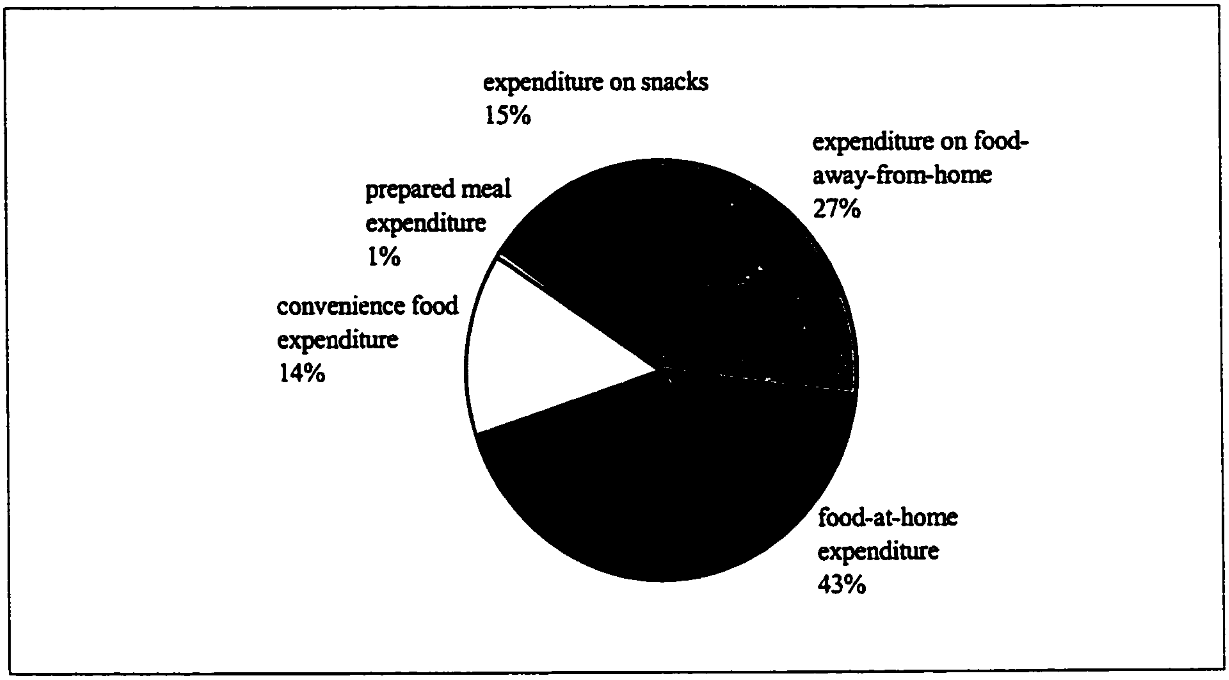
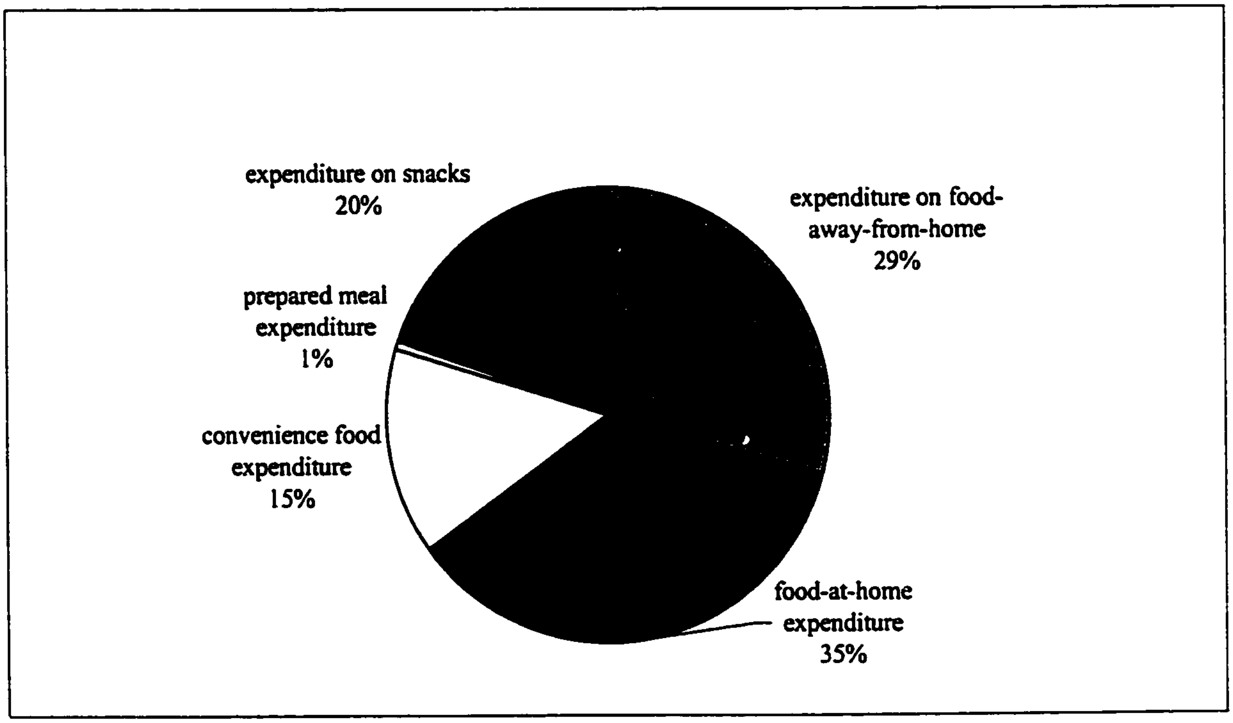


Figure 2 Proportions of Food Expenditures according to FFES data, 1992



Figures 1 and 2 indicate that the proportion of expenditure on food-away-from-home (FAFH) by 1992 increased 2% since 1986. The average share of snack expenditure increased by 5%, and it accounts for the largest change among all food categories. The convenience food expenditure share increased by 1% and the share of prepared meal expenditure remains unchanged. The expenditure share of food-at-home decreased by 8%. In general, the snacks and food-at-home expenditure has shown large shifts. Since the snacks category includes fruits, yogurt, etc, this may suggest a healthier eating trend developing during these years in Canada. Further exploration of this point is pursued in the estimation part of this study.

4.4.2 Demand Determinant Variables

The determinants of demand for the various categories of food include price and income, along with socioeconomic and demographic variables. The major household characteristic variables incorporated in the estimation model are listed in Table 4.4.2. The price variables for the different food categories will be discussed in section 4.5.

Table 4.4.2 indicates that in 1986, 55.7% of household managers were employed full-time while in 1992 this number decreased to 45.1%. The number of unemployed household heads increased from 23.9% for 1986 to 31.5% for 1992. These sample statistics are consistent with the unemployment rate published by Statistics Canada[18], where the unemployment rate is 9.6% for 1986 and 11.3% for 1992. The *urban* variable shows that more than 87% percent of the sample households are in urban areas. The gender variable of the household manager has increased from 0.705 to 0.726, which demonstrates that more than half of the households are headed by females and this ratio has reached 72.6% in 1992. In 1986, around 66% of the sample households consisted of married people, and this number had decreased by 1.4% six years later. The number of working wives was greatly reduced from more than one-third of the households in 1986 to only 14.1% in 1992, and the average age of household managers increased by seven months in 1992. In 1986, 10% of the households had children aged 0-15, and this number increased to 35.4% by 1992. The average number of full-time earners in this data

18 Statistics Canada Time-series database CANSIM matrix 3472, label D984954.

sample is about 0.8, and this number decreased a little in 1992[19]. The number of persons per household is around 2.65 in 1992 compared with 2.72 in 1986. The immigrant arrival year variable is designed the by numbers 1 -10 indicating nine different periods from before 1946 to 1992 and non-immigrant (Canadian born). The mean of this variable is 1.48 for yr.86 and 1.72 for yr.92, indicating that most of the survey participants are Canadian born or early immigrants, (1= Canadian born, 2=before 1946, 3=1946-55, 4=1956-60, 5=1961-65, 6=1966-70, 7=1971-75, 8=1976-80, 9=1981-85, 10=1986-92). Seasonal/quarterly dummies show that the sample data are evenly distributed around the survey year. Regional dummies indicate that people residing in Ontario make up the largest sample for FFES data, whereas households in Alberta provide the smallest sample. Statistics on education levels demonstrate that household heads with secondary education consist of the largest part in this sample. The education levels of household heads have increased during the six-year period. In 1992, the average percentage of household heads who have post-secondary education or diplomas increased by 1.1%–5.8% compared with 1986, and the average percentage of household heads who have only secondary education has decreased by 3.8%. The statistics on household compositions indicate that married-couple households account for the largest part of the sample, and households of *married couples with single child* have the largest percentage.

19 This number is consistent with the mean of 45% of household managers having full time employment and 14% of wives working because household heads are not confined to males and 14% is only the number of female spouses.

Table 4.4.2 Statistics of Socio-Demographic Variables from FFES Data*

Variable category and names	*1986* Mean	Std.Dev.	*1992* Mean	Std.Dev.
Birth Country of Household Managers				
Canada born*	0.838	0.369		
West Europe*	0.083	0.276	0.064	0.245
Southeast Europe*	0.041	0.198	0.033	0.177
Asian-pacific*	N/A+	N/A+	0.026	0.160
Other nations*	0.039	0.193	0.024	0.152
Employment Status of Household Managers				
Full-time employed*	0.557	0.497	0.451	0.498
Not employed*	0.239	0.426	0.315	0.465
Household Residing in Urban Area	0.894	0.308	0.873	0.332
Gender of household head (0=male,1=female)*	0.705	0.456	0.726	0.498
Household with Married Household head*	0.661	0.473	0.647	0.478
Household with Presence of Working Woman *	0.381	0.486	0.141	0.348
Age of Household Manager	45.45	16.259	46.00	15.94
Households with Children*	0.103	0.300	0.354	0.478
Number of Full-time Earners in Household	0.828	0.767	0.808	0.784
Household Income Before Tax	32,972.5	23,217.7	41,208.4	30,468.3
Total Household Size (number of persons)	2.713	1.397	2.650	1.370
Immigrant Arrival Year	1.482	1.632	1.724	2.004
Survey Time (Quarterly Dummy Variables)				
Q1 (First quarter)*	0.255	0.436	0.245	0.430
Q2 (Second quarter)*	0.250	0.434	0.253	0.435
Q3 (Third quarter)*	0.246	0.431	0.251	0.434
Q4 (Fourth quarter)*	0.249	0.432	0.245	0.433
Living Province (Regional Dummy Variables)				
G1 (Atlantic province dummy)*	0.198	0.398	0.232	0.422
G2 (Province of Quebec dummy)*	0.193	0.394	0.186	0.389
G3 (Province of Ontario dummy)*	0.241	0.428	0.238	0.426
G4 (Manitoba and Saskatchewan)*	0.137	0.343	0.154	0.361
G5 (Province of Alberta dummy)*	0.099	0.299	0.086	0.281
G6 (Province of British Columbia)*	0.129	0.336	0.104	0.305
Education Levels of Household Manager				
Edu1 (Less than 9 years of education)*	0.177	0.381	0.153	0.360
Edu2 (Secondary education dummy)*	0.450	0.498	0.412	0.492
Edu3 (Some post secondary education)*	0.119	0.324	0.130	0.336
Edu4 (Post sec certificate, diploma)*	0.119	0.324	0.177	0.382
Edu5 (University degree)*	0.134	0.341	0.127	0.333
Family Composition				
HC1 (One person household)*	0.212	0.408	0.214	0.410
HC2 (Married couple household)*	0.235	0.424	0.254	0.435
HC3 (HC2 with single child)*	0.393	0.488	0.361	0.480
HC4 (HC2 with relative nonrelative)*	0.031	0.172	0.034	0.181
HC5 (Single parent only)*	0.078	0.268	0.078	0.268
HC6 (Other household with relative)*	0.029	0.169	0.027	0.163
HC7 (Other non married couple household)*	0.022	0.146	0.030	0.172

*Note: Variables with * are dummy variables (=1 for households belonging to this category, 0 otherwise). Income Before Tax is a continuous variable, and other variables are indexes. Some variables in this table are not included in the estimation models in order to eliminate collinearity problem. Details are discussed in Chapter 5.

4.4.3 Data Problems

Reported zero expenditures are a major problem with FFES data. The number of zeros in 1986 and 1992 data are indicated in the following table 4.43.

Table 4.4.3 Numbers of Households Zero Expenditure[20]

		number of zeros in food expenditure data set					
year	Sample size	total food expenditure[21]	FAFH	FAH	COV	MEAL	SNK
1986	10125	199 (1.97%)	2310 (22.81%)	333 (3.29%)	563 (5.56%)	8312 (82.09%)	641 (6.33%)
1992	10657	161 (1.51%)	2131 (20.0%)	374 (3.51%)	593 (5.56%)	8789 (82.47%)	525 (4.92%)

Note: The numbers in this table are the numbers of households. Expenditure in each category is aggregated food expenditure. Zero total food expenditure indicates that no consumption was recorded in any aggregated food category in the survey period.

Table 4.4.3 indicates that fewer than 2% of households reported zero expenditure in total food expenditure, while prepared meal expenditure comprises the largest number of zeros in both 1986 and 1992. More than one-fifth of sample households reported zero expenditure for food-away-from-home. For the other three types of expenditures (FAH, convenience food and snacks), none of the zero expenditures makes up over 7% of the sample. The number of zeros for FAH, convenience food and snacks is less due to the aggregation of detailed food items in each group. However, selection bias still exists as long as the zero expenditure cannot be eliminated from the sample data.

4.5 Price Adjustment

Prices for the five food categories are not provided by the FFES and must be derived from existing variables. First, following Deaton (1988), unit values of detailed food items within each food category are obtained by dividing expenditures by their corresponding

20 Expenditures are aggregated expenditures for each food category.

21 Here recorded zero in total food expenditure denotes the number of households that did not report food expenditures on the survey week for unknown reasons.

quantities. The quantities are recorded in gram equivalents with the exception of FAFH, which is recorded as the actual number of meals. The price for each food category is equal to a weighted average of unit values where expenditure share is the weighting variable. To make unit price values measurement free in units, they were normalized by dividing the means across households before aggregation[22] (Yen and Roe 1989). The aggregated prices for different food groups are specified as follows:

$$p_{ag} = \sum_{i=1}^{s} w_{is} \frac{u_{is}}{\bar{u}_{is}} \tag{4.5.1}$$

where p_{ag} is the vector of aggregated food prices for different categories;

u_{is} is the unit value for detailed food items;

$\bar{u}_{is}$ is the mean of u_{is} across sample households ;

w_{is} is the expenditure share of the ith item of a particular food category.

Unit value aggregation was undertaken using SPSS version 9.0 (SPSS *Inc.*1999).

Following Cox and Wohlgenant (1986), the quality adjustments were made to aggregated prices by regressing P_{ag} on socioeconomic variables. Because selection bias was not addressed in Cox and Wohlgenant's (1986) study, and this should be considered when sample data contain many zeroes, the inverse Mills ratio was considered in the adjustment process (Park and Capps 1997)[23]. Three methods of price adjustment were then implemented tc gain a better understanding of these processes.

Method 1: The inverse Mills ratio is incorporated into regressor vectors of the price adjustment model, and the summation of predicted regional and seasonal effects is added to the adjusted price. The regression model for this version of price adjustment is specified as:

$p_{ag} = f_i$ *(country of birth, employment status, urban residence, sex, marital status, working wives, age, presence of children, number of full time earners, income before tax, family composition, household size, immigration arrival year, regional and seasonal dummies, IMR)* + ϵ_i (4.5.2)

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22 Quantity of detailed food items is recorded in different measurement units, including grams and ml. Hence aggregation of unit values without normalization are not appropriate..

23 In this case the decision on participation and price adjustment process can be considered as a two-sage simultaneous selection process.

where p_{ag} is the aggregated food price to be adjusted and *IMR* is the appropriate inverse Mills ratio. The adjusted price is specified as:

$$P_j^* = \hat{\alpha} + \sum \hat{\beta}_\Delta * \Delta + \hat{\epsilon}_j \qquad (4.5.3)$$

where Δ is the vector of quarterly and regional dummy variables, $\hat{\beta}_\Delta$ is the estimated coefficients for Δ, and $\hat{\alpha}'$ is the intercept. For non-purchasing households, the adjusted price is approximated by the intercept $\hat{\alpha}$. The adjusted price P_j^* eliminated the embodied socioeconomic and demographic effects from the unit values and kept the regional/seasonal supply factors.

Method 2: The inverse Mills ratio is not included in the regressor vectors, but summation of predicted regional and seasonal effects is added to the adjusted price[24]. The regression model for this version of price adjustment is specified as

$p_{ag} = f_i$ *(country of birth, employment status, urbanization, sex, marital status, working wives, age, presence of children, number of full time earners, income before tax, family composition, household size, immigration arrival year, regional and seasonal dummies)* $+ \epsilon_i$ (4.5.4)

where the inverse Mills ratio (*IMR*) is removed from equation (4.5.2) of model 1. The adjusted price from method 2 is specified as:

$$P_j^* = \hat{\alpha}' + \sum \hat{\beta}'_\Delta * \Delta + \hat{\epsilon}_j' \qquad (4.5.5)$$

where $\hat{\beta}'_\Delta$ is the estimated coefficients for Δ, and $\hat{\alpha}'$ is the intercept.

Method 3: Neither the inverse Mills ratio nor summation of predicted regional and seasonal effects is incorporated into the adjustment process[25]. The regression model for this version of price adjustment is also specified as equation 4.5.4, but the adjusted price for method 3 is specified as:

$$P_j^* = \hat{\alpha}' + \hat{\epsilon}_j' \qquad (4.5.6)$$

Dong et al (1998) employed a bivariate system in price adjustment by suggesting that price adjustment should be a simultaneous process along with the correction of

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24 This model is derived from the method of Cox et al (1986). We found that seasonal and regional dummies are significant in the regression, so they are incorporated into the model.

25 This model is equivalent to Cox et al (1986)'s specification because they found that regional and seasonal dummies are not significant in the model and eliminated them.

selection bias for demand function (i.e., the error terms of price adjustment estimation and demand function are correlated). Since the estimation of bivariate system involves considerable programming, we still followed the conventional Cox et al's (1986) method for price adjustment, in which the price adjustment stage and the demand estimation stage are considered as two independent selection processes.

The average of the aggregated price indices before and after adjustment are provided in the Table 4.5.1. The estimation results for the price adjustments are not listed in this thesis but can be provided by the author on request.

Table 4.5.1 Average Aggregated Price Index with and without Adjustment

	1986				*1992*			
	Non-adjusted	*Adjusted*			*Non-adjusted*	*Adjustment*		
Category		Model 1	Model 2	Model 3		Model 1	Model 2	Model 3
FAFH	0.77	1.28	1.27	1.28	0.76	1.17	1.02	0.96
FAH	0.98	1.16	1.13	1.14	0.99	1.11	0.99	0.96
COV	0.97	1.17	1.12	1.17	0.99	1.21	1.07	1.11
MEAL	1.01	1.07	1.07	1.11	1.01	1.22	1.15	1.13
SNACK	0.96	1.19	1.14	1.13	0.98	1.36	1.33	1.29

The adjusted prices for all food categories are equal to or higher than the unadjusted ones. The adjusted prices are explanatory variables ready to be used in the second stage of the demand estimations using the Heckman procedure. Because the adjusted prices are generated variables which may include some endogenous effects, the two stage least squares (2SLS) regression technique is used in the second stage estimation process.

Chapter 5 Single Demand Equation Estimation with Selection Bias

Model estimation was performed using Limdep™, Windows version 7.0 (*Econometric Software Inc*, 1998,1999). Adjusted prices were incorporated into both the single equation and demand system estimation procedures. In this chapter, results of the single equation estimation are presented, including the discussion of different sub-sample comparisons.

5.1 Estimated Parameters

In the single equation estimation (Engle equation), expenditures of five food categories are dependent variables, with price, income and socioeconomic variables as explanatory variables. Prices were entered in log forms since doing so simplifies the elasticity calculation process. This procedure avoids using quantity variables of aggregated food categories in this study, because the quantities of major food categories cannot be easily obtained by adding up the quantities of detailed food items due to differences in measurement units. Elasticity formulas for the log form have been discussed in section 3.5.

Single demand equations using 1986 and 1992 data are estimated with prices obtained from three different adjustment methods (equation 4.5.2-4.5.6, discussed in section 4.5). Probit and selection models are estimated consecutively with the inverse Mills ratio obtained from probit estimation automatically taken into the second step by Limdep™. The Probit results are provided in Appendix 3. The definitions of the explanatory variables are provided in Appendix 7. The second stage selection models are estimated in three model forms, with the adjusted prices from three different adjustment methods respectively. Models with unadjusted unit price values are also estimated but results cannot be obtained due to the collinearity problem. Hence, price adjustment process is considered necessary in this study. The estimated parameters of the model 1[26] for selection are presented in Tables 5.1.1 to Table 5.1.10 for the five food categories.

26 Method 1 of price adjustment is used for single demand equation model 1.

Results of model 2 and model 3 [27] are provided in Appendix 4. There are very few differences in terms of the estimated results of the three model versions, either in coefficients or model significance. The estimated parameters that are statistically significant at 5% and 10% levels are indicated with single and double asterisks respectively.

Estimations with 1986 and 1992 data are conducted separately. To eliminate collinearity problems[28], choices of right-hand-side variables are slightly different for 1986 and 1992 application. The dummy variables for country of birth in 1986 data and household composition in 1992 data are eliminated from the regressor vectors. The choice of regional dummies is also different for the two years. The dummy variables for the province of British Columbia (GC6) for 1986 and the provinces of Manitoba and Saskatchewan (GC4) for 1992 are also removed from the regressors to avoid collinearity. Tables A2-1 and A2-2 (both in Appendix 2) provide the probit estimation results for the five food categories. Most of the coefficients are statistically significant. Results for the FAFH equation indicate that households with married couples, female household heads, higher income levels and various educational levels have positive influences on the choice of FAFH. Households with younger, Canadian born household heads or headed by earlier immigrants also have positive attitude towards FAFH. Households with children and unemployed family heads have a negative effect on the choice of FAFH. The food-at-home (FAH) estimates demonstrate that households with married couples, large family sizes, male and senior household heads have a positive effect on the choice of FAH, while households with unemployed heads and higher incomes are less likely to purchase FAH. The probit estimates for prepared meals indicate that households residing in urban areas, having children, with full-time working household heads, larger family size and more than one full-time earner have a positive influence on expenditure on prepared meals. Households with higher income levels are less likely to purchase prepared meals. Results for convenience foods and snack expenditures suggest similar effects as those for FAH. Because the results from the probit model only reflect household's decision on

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27 Methods 2 and 3 of price adjustment are used for single demand model 2 and model 3 respectively.

28 Because many dummy variables were included as the independent variables, collinearities occurred among some of these variables.

participation, it does not thoroughly reveal the factors affecting purchase amounts for participating households. Detailed discussion of consumption behavior for these food categories will be based on the second-stage selection model results and is given in Tables 5.1.1 to 5.1.10.

Table 5.1.1 Estimated Coefficients of Single Demand Equation for FAFH, 1986

Variable	*Coefficient*	*t-ratio*	*Variable*	*Coefficient*	*t-ratio*
CONSTANT	4.0577	2.562			
FULLEMPL	-0.2683	-0.096	GC4	2.9128	0.922
NOEMPL	8.1932	1.673**	GC5	9.4106	2.864*
URBAN	2.9747	1.083	EDU2	-4.4723	-1.448
SEX	-14.0874	-2.885*	EDU3	-11.4816	-2.36*
MARRIED	-33.3023	-1.862*	EDU4	-9.8418	-2.12*
WW	-2.8943	-0.611	EDU5	-2.0438	-0.429
AGE	0.0106	0.118	HC1	-8.6860	-1.480
CHILDREN	-10.4693	-3.417*	HC2	15.2579	0.883
NFEARNER	4.6839	2.474*	HC3	12.3410	0.726
INCOME	0.0006	10.56*	HC4	13.1550	0.751
HSIZE	-0.5625	-0.497	HC6	-9.6698	-1.578
ARRIVAL	0.7640	1.255	HC7	-8.7713	-1.216
Q1	-2.2830	-1.012	PFAFH	57.7364	16.727*
Q2	-1.6967	-0.733	PFAH	5.5800	0.912
Q3	7.5541	3.312*	PCOV	-1.8077	-0.427
GC1	2.5016	0.778	PMEAL	4.6106	0.921
GC2	6.9494	2.365*	PSNK	13.0937	3.328*
GC3	5.2748	1.881**	LAMBDA	-59.8191	-4.490*

Model1: R-squared = .191931, Adjusted R-squared = .18809 Model test: F [37, 7777] = 49.92
*Statistically significant at 5% critical level. ** Statistically significant at 10% critical level.

Tables 5.1.1 and A4-1 (in Appendix 4) provide the single-equation estimates of food-away-from-home consumption for the year 1986. Results of the three models do not demonstrate much variation in estimated coefficients and calculated t-ratios despite the different price adjustment processes used in these models. One third (12 out of 36) of the estimates are statistically significant for all the models. Households with female, married managers impact negatively on preference for FAFH. Presence of children in a household is negatively correlated with FAFH expenditure. In contrast to expectations, households headed by unemployed managers have greater expenditures on FAFH. The number of full time earners and total income before tax have positive effects on FAFH expenditure. Education level 3 (some post-secondary education) and 4 (post secondary certificate or diploma) are significant at 1%–10% critical levels and have negative effects on FAFH expenditure. The education coefficients that correspond to a university degree (EDU level 5) are not statistically significant, indicating that higher education levels do not necessarily have a significant effect on FAFH expenditure. The seasonal/quarterly dummy is only significant in the third quarter and shows a positive effect, suggesting that summer and early autumn (July to September) may be the relatively favorite seasons for Canadians to eat out. The regional dummies are statistically significant and positive in GC3 (Ontario) and GC5 (Alberta), compared to the reference group GC6 (British Columbia). The household composition estimates are not statistically significant in food-away-from-home estimation equations, indicating that this variable does not have a significant effect on FAFH for the 1986 data.

In terms of price variables, the results indicate that the price of FAFH is a significant, negative influence on expenditure. The price of snacks is the only other statistically significant price. Contrary to expectations, no other food prices are strongly related to food-away-from-home expenditures. The detailed exploration of price effect is focused on elasticities and discussed in section 5.2. The inverse Mills ratio (LAMBDA), which is derived from the first step probit estimation, is highly significant at the 1% critical level. This indicates that the first stage selection process is important in the FAFH expenditure estimation procedure.

Tables 5.1.2 and A4-1 provide the FAFH estimates for 1992. More than one third (13 out of 35) of the estimates are statistically significant for each of the models. The parameter estimates indicate that people born in Asian Pacific countries have significant preferences for FAFH consumption. In addition to the socioeconomic variables that are statistically significant for the 1986 application, the full-time employment dummy variable is significant for the 1992 data. However, households with a manager who works full-time are not associated with a significant positive influence on FAFH. Education levels are no longer significant for the 1992 data. The socioeconomic variables that are statistically significant in 1992 have the same effects on FAFH as for 1986. As in 1986, the seasonal dummy is still significant for the third quarter, indicating that summer is the favorite season for Canadians to eat out. The only statistically significant regional dummy is GC5 (Alberta) for 1992, indicating Alberta residents' strong preferences for FAFH.

Table 5.1.2 Estimated Coefficients of Single Demand Equation for FAFH, 1992

Variable	*Coefficient*	*t-ratio*	*Variable*	*Coefficient*	*t-ratio*
CONSTANT	5.798327	2.253*			
WEUROPE	8.1793009	1.237	Q2	0.1814026	0.063
SEUROPE	4.5262088	0.519	Q3	7.4663892	2.632*
ASIA	38.655159	3.626*	Gc1	-3.2836669	-0.68
OTHERN	9.4702048	0.857	Gc2	5.1398668	1.297
FULLEMPL	-9.2290203	-2.526*	Gc3	4.7195007	1.308
NOEMPL	2.4953419	0.543	Gc5	9.3642611	2.094*
URBAN	4.680377	1.488	Gc6	-0.5236665	-0.131
SEX_	-11.224804	-4.467*	Edu2	1.1679721	0.273
MARRIED	1.8129755	0.572	Edu3	3.1309448	0.519
WW	-5.3246355	-1.382	Edu4	2.8317855	0.467
AGE	0.15774	1.382	Edu5	4.0169007	0.635
CHILDREN	-6.1700992	-1.928*	PFAFH	55.630168	19.063*
NFEARNER	12.671226	4.537*	PFAH	4.7582311	0.876
INCOME	5.37E-04	8.916*	PCOV	15.361799	3.127*
HSIZE	-1.9230879	-1.389	PMEAL	-0.7753724	-0.678
ARRIVAL	-1.471759	-1.184	PSNK	19.815588	4.062*
Q1	1.3660881	0.483	LAMBDA	-58.358911	-2.937*

Note: ASIA = People who were born in Asian Pacific countries (=1, 0 otherwise)
WEUROPE = People who were born in Western European countries (=1, 0 otherwise)
SEUROPE= People born in Southern and Eastern European countries (=1, 0 otherwise)
OTHERN= People who were born in any other country besides Canada and the above choices.
All other variables have the same definitions as those for the 1986 estimation.

Model1: R-squared = .160341, Adjusted R-squared = .15688 Model test: F [35, 8490] = 46.32,
*Statistically significant at 5% critical level.

Price variables for FAFH are highly significant for the 1992 application. In addition to the price of snacks as in the 1986 application, the price of convenience food is also statistically significant. The inverse Mills ratio (LAMBDA) also indicates a significant estimate.

To investigate the possible structural changes between 1986 and 1992, we pooled two years data and conducted the Chow (1960) test on FAFH results. Because the choices of explanatory variables for original yr. 86 and yr. 92 estimations are slightly different (to preclude the collinearity problem), we removed those unpaired variables (i.e., country of birth, household composition, and regional dummies) and implemented the pooled and unpooled estimation with only 25 paired variables. In this case, the unpooled estimations for 1986 and 1992 are re-estimated using the same single equation models with only 25 variables as explanatory variables, which is a little different from the original specification using more than 30 variables. Because this simplification is only used for the purpose of investigating the structural changes and to make the Chow (1960) test valid, the simplified unpooled estimates for 1986 and 1992 are not appropriate to compare with the original unpooled specification. The estimated coefficients for pooled and the revised unpooled samples are not presented here but can be retrieved by contacting the author. The Chow (1960) test result of structural change for FAFH is equal to 5.46, which is greater than the critical value F (25, 20470)≈1.46, [29] suggesting that structural change in expenditure patterns occurred between 1986 and 1992.

The general estimation results for the FAFH equations for both 1986 and 1992 provide preliminary information about which variables may influence FAFH expenditure. To further investigate the influence of socio-demographic variables and to obtain an accurate picture of price relationships, we consider the elasticities of prices and social-demographic variables. A detailed description of calculated elasticities for all the continuous variables from the single equation estimation is presented in section 5.2.

Table 5.1.3 Estimated Coefficients of Single Demand Equation for FAH, 1986

Variable	*Coefficient*	*t-ratio*	*variable*	*Coefficient*	*t-ratio*
CONSTANT	3.490186	3.72*			
FULLEMPL	2.23718101	1.161	GC4	-11.47894056	-5.255*
NOEMPL	-11.09010244	-4.2*	GC5	-3.194360496	-1.361
URBAN	0.846580276	0.464	EDU2	-0.672680253	-0.356
SEX	0.354165769	0.122	EDU3	0.377299289	0.131
MARRIED	10.09949179	0.808	EDU4	2.691446774	1.029
WW	-2.873822643	-0.966	EDU5	2.678985074	0.872
AGE	0.573262115	10.552*	HC1	-9.547130585	-2.112*
CHILDREN	-13.5238974	-6.771*	HC2	-0.958187565	-0.081
NFEARNER	9.67E-02	0.075	HC3	6.552844122	0.567
INCOME	2.38E-04	6.649*	HC4	5.340938581	0.447
HSIZE	16.52842636	20.803*	HC6	-0.372705881	-0.088
ARRIVAL	0.76712425	1.875**	HC7	2.410701195	0.485
Q1	-1.456890546	-0.918	PFAFH	6.367860587	3.52*
Q2	-2.125167306	-1.394	PFAH	12.06475957	3.101*
Q3	-4.651576849	-2.334*	PCOV	9.072672238	3.184*
GC1	-2.146878493	-1.084	PMEAL	-5.780442756	-1.614**
GC2	10.08228739	5.069*	PSNK	3.503381537	1.325
GC3	-7.444974238	-3.427*	LAMBDA	35.64409172	1.12

Model1: R-squared =. 304035, Adjusted R-squared =. 30139, Model test: F [37, 9754] = 115.16
*Statistically significant at 5% critical level. **Statistically significant at 10% critical level.

29 Pooled sample size n1+n2=20520, k=25, n1+n2-2k=20470. In most textbooks, the F distribution table only provides critical values with up to 1000 degrees of freedom, so this value is approximated by the last row of available values from the table. This approximation is also applied in later specifications of this study.

Tables 5.1.3 and A4-2 provide the single-equation estimates of food-at-home consumption for 1986. The performance of each of the three versions of models based on the R-square and model test is quite similar in terms of statistical significance. Some 13 out of 36 of the estimates are statistically significant in each model. The age of the household head and presence of children are significant at the 5% critical level. The estimates indicate that the older the household head, the greater the expenditure on FAH. Contrary to expectations, the presence of children does not increase expenditure on FAH. Gender and marital status are not statistically significant in the FAH estimations. This is plausible considering that FAH is a necessity and may not be affected by these two demographic attributes. The number of full time earners and the education level are also insignificant in the FAH estimation, possibly due to the same reason as proposed above. Total household size and income before tax are highly significant as expected, and each of these has a positive effect on FAH expenditure. The third quarter (July-September) seasonal/quarterly dummy is significant, and this has a negative effect on FAH expenditure. Compared to significant and positive effects of the third quarter for FAFH estimation (Table 5.1.1), the FAH result suggests that summer and early autumn are not favorite seasons for Canadians to eat at home, and more eating out may occur. Regional dummies are statistically significant and positive in GC2 (the province of Quebec), negative in GC3 (the province of Ontario) and GC4 (the provinces of Manitoba and Saskatchewan), suggesting that people in different provinces have different preference for FAH. The only household composition estimate that is significant is HC1 (unattached individual, single) and has a negative impact, which suggests that single person households may not prefer cooking at home or may be less able to do so.

Price variables are statistically significant for FAH, FAFH and COV, suggesting that these three prices should be most closely related to food-at-home consumption. The inverse Mills ratio (LAMBDA) is not significant. This result is consistent with the lower percentage of zero expenditures in 1986 FAH data and may suggest a small effect of selection process in the first stage for FAH estimation.

Table 5.1.4 Estimated Coefficients of Single Demand Equation for FAH, 1992

Variable	*coefficient*	*t-ratio*	*variable*	*coefficient*	*t-ratio*
CONSTANT	6.3658763	3.326*			
WEUROPE	0.3353358	0.104	Q2	3.0285635	2.063*
SEUROPE	14.363094	3.721*	Q3	-2.9020679	-2.003*
ASIA	0.2416522	0.046	GC1	1.551566	0.855
OTHERN	3.2778919	0.624	GC2	13.533358	6.952*
FULLEMPL	-4.1974058	-2.23*	GC3	0.2081193	0.119
NOEMPL	-7.1919386	-4.373*	GC5	1.7401101	0.8
URBAN	3.5180729	2.246*	GC6	7.4090406	3.33*
SEX	1.4772589	1.123	EDU2	2.8616654	1.678**
MARRIED	18.350368	9.319*	EDU3	4.6600728	2.165*
WW	-2.7464335	-1.361	EDU4	6.3053251	3.048*
AGE	0.5592656	11.735*	EDU5	10.380959	4.543*
CHILDREN	-2.323458	-1.435	PFAFH	5.8992264	4.215*
NFEARNER	1.3120556	0.929	PFAH	8.707328	3.266*
INCOME	2.11E-04	8.938*	PCOV	7.2920399	3.225*
HSIZE	15.636448	22.042*	PMEAL	5.1070311	6.91*
ARRIVAL	2.0371314	3.32*	PSNK	5.9515893	2.45*
Q1	0.1466039	0.103	LAMBDA	26.512676	1.647**

Model1: R-squared = .281877, Adjusted R-squared = .27942 Model test: F [35,10247] =114.92,
*Statistically significant at 5% critical level. **Statistically significant at 10% critical level.

Table 5.1.4 and A4-2 provide the FAH estimates for 1992. Although results from 1992 parameters present a lower R^2 than in 1986, more variables have significant estimated parameters than in 1986. There are 22 out of 35 estimates that are statistically significant for all the three model versions. The Chow (1960) test statistic for structural change on pooled 1986 and 1992 data is equal to 25.07, which is greater than the critical value F (25,20470)≈1.46. This suggests that structural change occurred between 1986 and 1992 for FAFH consumption.

Estimated parameters for 1992 indicate that people who were born in southeast European countries have stronger preferences (coefficient =14.36, t-ratio=3.721) for FAH consumption than people from other ethnic backgrounds. Unlike in 1986, employment status (full time work or unemployed) and marital status are statistically significant for 1992 data at a 5% critical level. The results indicate that households headed by a full-time employed person and those headed by an unemployed person have the similar negative influence on FAH expenditure. Besides the socio-demographic variables that are significant and have same effects for both 1986 and 1992, immigrant arrival year is significant and positive for the 1992 application. This implies that the later the immigrant comes to Canada, the more reliance is placed on food-at-home consumption within their choices. Estimates of education levels are all statistically significant and positive, compared to households with managers having less than 9 years of education. This indicates that FAH is a basic need no matter the level of education. However, the results indicate that preferences for FAH increase as the education level of the household head increases. The seasonal/quarterly dummy is significant and positive in the second quarter (April to June) and negative in the third quarter, which conforms to the 1986 result. The regional dummies are positive in all provinces but only statistically significant in GC2 (Quebec) and GC6 (British Columbia) compared to the omitted choice of GC4 (Manitoba and Saskatchewan) for 1992.

Price variables for FAH and the income before taxes variable (INCOME) are each highly significant for 1992. The inverse Mills ratio (LAMBDA) estimate is also significant. This may reflect the higher percentage of zeros in the FAH expenditure data for 1992.

Table 5.1.5 Estimated Coefficients of Single Demand Equation for COV, 1986

Variable	*coefficient*	*t-ratio*	*variable*	*coefficient*	*t-ratio*
CONSTANT	-0.62132	-2.071*			
FULLEMPL	2.0534519	3.292*	GC4	-0.3557845	-0.488
NOEMPL	-2.2571789	-2.645*	GC5	1.1908953	1.523
URBAN	-0.3327906	-0.56	EDU2	-0.365268	-0.628
SEX	-1.6281608	-1.684	EDU3	-1.3783387	-1.524
MARRIED	3.0253332	0.738	EDU4	-0.8556872	-1.005
WW	-0.182016	-0.201	EDU5	-2.0469039	-2.228*
AGE	8.33E-02	3.781*	HC1	0.6187583	0.363
CHILDREN	-2.2558628	-3.48*	HC2	-0.2078293	-0.053
NFEARNER	-1.1358003	-2.737*	HC3	2.9794587	0.793
INCOME	5.20E-05	4.291*	HC4	-0.4085475	-0.105
HSIZE	6.4258785	25.238*	HC6	2.3065406	1.642
ARRIVAL	-0.1375589	-1.04	HC7	2.4984748	1.581
Q1	0.2509448	0.439	PFAFH	1.3049158	2.403*
Q2	-0.4157291	-0.833	PFAH	2.5496894	1.801*
Q3	-0.4612648	-0.786	PCOV	6.1226422	5.896*
GC1	0.1251841	0.192	PMEAL	-3.7753372	-3.221*
GC2	0.6199255	0.903	PSNK	1.7153084	1.95*
GC3	0.1507787	0.233	LAMBDA	3.5854093	0.412

Model1: R-squared = .309946, Adjusted R-squared = .30727 Model test: F [37, 9524] = 115.62
*Statistically significant at 5%-10% critical level.

Convenience food (COV) estimates for 1986 are provided in Tables 5.1.5 and A4-3. The three versions of models for COV consumption are similar in statistical significance but differ slightly in coefficient magnitudes. Employment status coefficients are significant at the 5% critical level for households with full-time working managers.

However, households with unemployed heads have a significant negative influence on expenditure on consumed convenience food. Similar to the FAH estimation, gender and marital status are not statistically significant for the COV estimation. The age of household head parameter is significant and positive, indicating that the expenditure of COV increases in households with the older household heads. The presence of children and the number of full-time earners coefficient are significant and negative, showing that an increase in these two variables will lead to a decrease in COV consumption. Total household size and income before tax are highly significant and have positive effects, as in the other estimations. Coefficients of education level variables are all negative but only significant in educational level 5, suggesting that households headed by university degree holders may not prefer COV consumption. Seasonal/quarterly and regional dummies are insignificant in the COV estimation for 1986. The household composition estimates are also insignificant.

The price variables are all statistically significant, indicating that relationships exist between convenience food expenditure and prices of related foods. The inverse Mills ratio (LAMBDA) is not significant for 1986. This result suggests that the effect of the selection process in the first stage for COV estimation is minor for 1986.

Table 5.1.6 Estimated Coefficients of Single Demand Equation for COV, 1992

Variable	*Coefficient*	*t-ratio*	*Variable*	*Coefficient*	*t-ratio*
CONSTANT	-1.4759718	-2.045*			
WEUROPE	0.9616479	0.679	Q2	0.7285837	1.138
SEUROPE	1.5225884	0.916	Q3	3.26E-02	0.052
ASIA	-11.60905	-5.085*	GC1	-4.0093391	-5.113*
OTHERN	-5.7313706	-2.524*	GC2	-3.9560264	-4.658*
FULLEMPL	0.82592	1.016	GC3	-1.988379	-2.656*
NOEMPL	-2.3176185	-3.261*	GC5	0.1746881	0.185
URBAN	0.1717431	0.254	GC6	-1.2807249	-1.312
SEX	-0.1771062	-0.318	EDU2	-0.810942	-1.126
MARRIED	4.7096062	5.095*	EDU3	-7.42E-02	-0.081
WW	-1.4424589	-1.694**	EDU4	1.0062676	1.156
AGE	8.80E-02	4.093*	EDU5	1.3448807	1.356
CHILDREN	3.5216306	5.021*	PFAFH	0.9046739	1.493
NFEARNER	-0.5538314	-0.913	PFAH	1.0516659	0.907
INCOME	5.62E-05	5.553*	PCOV	8.2294898	8.154*
HSIZE	7.4314189	24.261*	PMEAL	3.2385586	8.941*
ARRIVAL	0.1094343	0.41	PSNK	1.4718062	1.37
Q1	-0.1664791	-0.27	LAMBDA	0.8852474	0.137

Model1: R-squared =. 290337, Adjusted R-squared = .28786 Model test: F [35, 10028] = 117.22
*Statistically significant at 5% critical level. **Statistically significant at 10% critical level.

Tables 5.1.6 and A4-3 provide the COV estimates for the 1992 data. 13 out of 35 coefficients are statistically significant for each of the models. The Chow (1960) test result of structural change for pooled 1986 and 1992 data is equal to 9.34, which is greater than the critical value F (25, 20470)=1.46, indicating that the structural changes occurred between 1986 and 1992 for COV consumption. The estimated coefficients imply that people born in Asian Pacific and other nations beyond the major categories have a significant and negative preference for COV expenditure. The coefficient of the age variable is statistically significant and positive for 1992, showing that COV consumption will increase with an increase in the household head's age. The significant and positive dummy for marital status and the presence of children implies that households with these characteristics generally spend more money on COV. Education levels are insignificant for 1992. Seasonal dummies are also insignificant, while the regional dummy variables are statistically significant and negative in GC1 (Atlantic Provinces), GC2 (Quebec) and GC3 (Ontario) for yr.92, suggesting that COV is a less favored choice in these provinces compared to British Columbia.

Only the price variables for COV and MEAL are significant in 1992. Income before tax and household size, as expected, have positive effects and are highly significant for 1992. The inverse Mills ratio (LAMBDA) is insignificant, as it was for 1986.

Prepared meal estimates for 1986 are provided in Tables 5.1.7 and A4-4. Only one of the coefficients is statistically significant in each version of the empirical model, which implies that the model for prepared meals does not fit the 1986 data well. The only statistically significant variable is the household composition variable HC1. The positive effect of this variable suggests that single person households are the largest buyers of prepared meals. All other coefficients, including total household size, income before tax, log price variables and inverse Mills ratios (LAMBDA) are insignificant in the prepared meals model fitted to 1986 data. These results suggest that the postulated single equation between prepared meal and current right-hand-side was not well established for the 1986 data.

Table 5.1.7 Estimated Coefficients of Single Demand Equation for MEAL, 1986

Variable	*coefficient*	*t-ratio*	*variable*	*coefficient*	*t-ratio*
CONSTANT	5.10E-03	2.439*			
FULLEMPL	-6.84E-03	-1.292	GC4	-7.11E-03	-0.769
NOEMPL	-7.57E-04	-0.169	GC5	-4.49E-03	-1.08
URBAN	-3.27E-03	-0.613	EDU2	1.48E-04	0.033
SEX	-2.27E-03	-0.447	EDU3	-1.32E-03	-0.247
MARRIED	3.36E-03	0.176	EDU4	-1.83E-03	-0.396
WW	-1.50E-03	-0.309	EDU5	-5.98E-04	-0.149
AGE	7.13E-05	0.8	HC1	1.82E-02	2.405*
CHILDREN	4.29E-03	1.039	HC2	-6.61E-03	-0.363
NFEARNER	2.14E-03	1.028	HC3	-7.59E-03	-0.427
INCOME	3.93E-08	0.322	HC4	-2.70E-03	-0.147
HSIZE	-6.84E-03	-1.514**	HC6	2.68E-03	0.319
ARRIVAL	-5.06E-04	-0.505	HC7	8.82E-03	0.903
Q1	1.84E-03	0.539	PFAFH	-3.74E-03	-1.321
Q2	2.38E-03	0.829	PFAH	4.16E-03	0.513
Q3	3.91E-03	0.806	PCOV	-1.41E-02	-1.311
GC1	-1.87E-02	-1.074	PMEAL	4.35E-02	1.19
GC2	-2.95E-03	-0.588	PSNK	3.56E-03	0.563
GC3	-6.03E-03	-1.07	LAMBDA	-4.59E-02	-0.879

Model1: R-squared = .161057, Adjusted R-squared = .14357, Model test: F [37, 1775] = 9.21
*Statistically significant at 5% critical level. **Statistically significant at 10% critical level.

Table 5.1.8 Estimated Coefficients of Single Demand Equation for MEAL, 1992

Variable	*Coefficient*	*t-ratio*	*variable*	*Coefficient*	*t-ratio*
CONSTANT	2.450839	0.328			
WEUROPE	-0.5247547	-0.54	Q2	-0.6790838	-1.747**
SEUROPE	0.5026751	0.411	Q3	-0.5722503	-1.46
ASIA	-1.6558187	-0.986	GC1	-0.7358452	-1.572
OTHERN	0.1790573	0.111	GC2	-0.9914723	-1.903*
FULLEMPL	-0.2734105	-0.547	GC3	-0.252859	-0.52
NOEMPL	-0.6922323	-1.552	GC5	1.1192451	1.681**
URBAN	0.2641034	0.601	GC6	0.186799	0.297
SEX	-0.1599965	-0.46	EDU2	-0.4991699	-1.058
MARRIED	-0.1856301	-0.433	EDU3	-0.7392113	-1.262
WW	-0.4672295	-0.885	EDU4	-0.3211943	-0.583
AGE	1.33E-02	1.059	EDU5	-0.6544566	-1.021
CHILDREN	0.3973641	0.946	PFAFH	4.46E-02	0.12
NFEARNER	0.3064284	0.833	PFAH	-0.8483894	-1.01
INCOME	7.59E-06	1.152	PCOV	1.3096279	1.85**
HSIZE	0.2899247	1.541	PMEAL	2.5435292	8.697*
ARRIVAL	0.1776322	0.966	PSNK	5.58E-04	0.001
Q1	-0.4163912	-1.094	LAMBDA	1.293134	0.629

Model1: R-squared = .072436, Adjusted R-squared = .05471 Model test: F [35, 1832] = 4.09
*Statistically significant at 5% critical level. **Statistically significant at 10% critical level.

Tables 5.1.8 and A4-4 provide the MEAL estimates for 1992 data. Results are similar to the 1986 application in model performance. Only 4 out of 35 coefficients are statistically significant. The Chow (1960) test result for structural change for pooled 1986 and 1992 data is equal to 3.28, which is greater than the critical value F (25,20470)≈1.46. This indicates that there were structural changes between 1986 and 1992 MEAL consumption, in spite of the insignificant estimates for both years. Estimated coefficients show that the second quarter (April to June) has a statistically significant and negative effect on prepared meal expenditure, while the regional dummy is statistically significant and negative in GC2 (Ontario).

The own price for MEAL is highly significant for 1992, as is the cross-price of COV. The Inverse Mills ratio (LAMBDA) presents a similar insignificant estimate to 1986. The contradiction between the large proportion of zeros and insignificant inverse Mills ratio may relate to the poor performance of the model. The fewer significant estimates in the prepared meals equation suggests that the single demand equation does not well fit the data.

Table 5.1.9 Estimated Coefficients of Single Demand Equation for Snack, 1986

Variable	*Coefficient*	*t-ratio*	*variable*	*Coefficient*	*t-ratio*
CONSTANT	1.667213	4.499*			
FULLEMPL	3.2129546	4.229*	GC4	-1.004367	-1.133
NOEMPL	-2.2740151	-2.248*	GC5	2.7875252	2.758*
URBAN	0.4819011	0.674	EDU2	1.5778823	2.28*
SEX	0.4211564	0.367	EDU3	3.3856872	3.071*
MARRIED	11.179933	2.917*	EDU4	4.0426622	4.094*
WW	-0.464629	-0.415	EDU5	6.5925475	5.63*
AGE	0.1902416	8.24*	HC1	0.6046343	0.333
CHILDREN	-3.4532522	-4.271*	HC2	-4.7183469	-1.325
NFEARNER	-0.6620856	-1.307	HC3	-1.161291	-0.332
INCOME	1.20E-04	8.823*	HC4	-5.3326484	-1.445
HSIZE	5.2119982	16.074*	HC6	3.5439207	2.078*
ARRIVAL	0.4135406	2.56*	HC7	4.6707038	2.449*
Q1	-1.0862408	-1.703**	PFAFH	0.9698355	1.448
Q2	0.5428393	0.905	PFAH	6.8009546	4.327*
Q3	0.1089346	0.154	PCOV	4.0481887	3.72*
GC1	1.2667217	1.618	PMEAL	-1.8021578	-1.277
GC2	6.3464294	8.072*	PSNK	8.5375629	8.091*
GC3	1.7381975	2.096*	LAMBDA	16.611234	1.818*

Model1: R-squared = .270823, Adjusted R-squared = .26800 Model test: F [37, 9556] = 95.92
*Statistically significant at 5% critical level. **Statistically significant at 5% critical level.

Estimates of the snack equation for 1986 are provided in Tables 5.1.9 and A4-5. Results of the three versions of models for snack consumption are quite similar in terms of both coefficients and statistical significance. There are 22 out of 36 of the estimates that are statistically significant, indicating a good fit of the model for the 1986 data. Most socio-demographic variables are statistically significant including dummy variables for employment status, marital status, age and presence of children. Household heads working full-time lead to an increase in snack consumption, while households headed by unemployed persons have an opposite effect. Married couple households have a positive effect on snack expenditure. An expansion in snack expenditure is associated with an increase in age of the household head. In contrast to our expectation, snack consumption is negatively associated with the presence of children in a household[30]. All educational level dummy variables are positive and statistically significant, and the preference for snacks increases with an increase in education levels. Seasonal dummies are insignificant, but regional dummies are significant and positive in GC2 (Quebec), GC3 (Ontario) and GC5 (Alberta), indicating higher expenditure on snack consumption in these provinces compared to Manitoba and Saskatchewan. The household composition dummy variables are significant and positive in two particular categories: HC6 (single-parent family) and HC7 (other spending unit with relatives only), implying that these two types of households have stronger preferences for snacks than the others.

Price variables are statistically significant for own price (SNK), and for prices of FAH and COV, showing that snack consumption is related to each of these prices. The coefficients on total household size and income before tax are positive and highly significant as is consistent with the general expectation. The inverse Mills ratio (LAMBDA) is significant for 1986, suggesting that the effect of selection process in the first stage for snacks estimation is important.

Tables 5.1.10 and A4-5 provide the snack estimates for the 1992 data. There are 23 out of 35 coefficients that are statistically significant for each of the three models. The Chow (1960) test result of structural change for pooled 1986 and 1992 data is equal to 32.32, which is much greater than the critical value F (25,20470) $\approx$1.46, indicating that there is evidence of structural changes between 1986 and 1992 in snack expenditures. Estimated coefficients on birth location imply that people who were born in southeast European countries have a positive attitude toward the purchase of snacks (coefficient=4.878, t-ratio=2.224) while people from Asian Pacific countries have a

30 This is likely due to the broad definition of snacks.

negative influence (coefficient = -8.839 t-ratio = -2.942) on snack expenditures. Households headed by an unemployed person exhibit a significant but negative relationship with snack expenditure. The gender of the household head has a positive and statistically significant effect, indicating that households headed by female managers spend more on snack purchases. As in the 1986 results, marital status and all education dummies are statistically significant at the 1% critical level. Married couple households have a preference for snack expenditures. Increases in education levels result in an expansion of snack expenditure. Seasonal/quarterly dummies are significant in the first and second quarter. These results indicate that snack consumption decreases in the first quarter (January to March) and increases in the second quarter (April to June) compared to the fourth quarter. Compared to the province of Manitoba and Saskatchewan (GC4), the regional dummy is statistically significant in GC1 (Atlantic provinces) and GC2 (Ontario) for 1992, whereas households in Ontario prefer to consume more snacks than in other provinces, and the Atlantic households generally spend less on snacks.

Table 5.1.10 Estimated Coefficients of Single Demand Equation for Snacks, 1992

Variable	*Coefficient*	*t-ratio*	*variable*	*Coefficient*	*t-ratio*
CONSTANT	2.1298376	-2.316*			
WEUROPE	-1.1034038	-0.604	Q2	2.889711	3.32*
SEUROPE	4.8780018	2.224*	Q3	-0.6326145	-0.774
ASIA	-8.8391883	-2.942*	GC1	-3.0886704	-2.93*
OTHERN	-1.637172	-0.55	GC2	4.7435546	4.482*
FULLEMPL	1.2292625	1.15	GC3	0.6250527	0.625
NOEMPL	-3.5150021	-3.791*	GC5	1.7854333	1.445
URBAN	-1.64E-02	-0.019	GC6	0.7507852	0.614
SEX	2.4239729	3.169*	EDU2	2.4236766	2.537*
MARRIED	8.014439	7.011*	EDU3	4.6957661	3.803*
WW	1.8099498	1.595	EDU4	6.7151687	5.714*
AGE	0.3604437	13.613*	EDU5	9.6227614	7.212*
CHILDREN	4.641445	5.063*	PFAFH	1.1934523	1.521
NFEARNER	-1.5729858	-1.967*	PFAH	5.1648442	3.417*
INCOME	1.32E-04	9.909*	PCOV	8.5139129	6.716*
HSIZE	8.4273815	20.823*	PMEAL	3.6640192	8.181*
ARRIVAL	0.9499164	2.732*	PSNK	15.174636	10.698*
Q1	-1.671503	-2.044*	LAMBDA	10.497026	1.336

Model1: R-squared = .291706, Adjusted R-squared = .28925 Model test: F [35, 10105] = 118.90
*Statistically significant at 5% critical level.

Price variables for food categories except FAFH are highly significant, indicating that cross-price effects related to snack consumption exist. Income-before-tax and total-household-size are also highly significant and positive. The Inverse Mills ratio (LAMBDA) is not significant for 1992.

In general, parameters estimated from the single-equation applications for both 1986 and 1992 provide a basic picture of Canadian household demand for each category of food relative to price and socio-demographic variables. The significance in most estimates indicates that the demand equation between the expenditures and explanatory variables exists. The own price, income and total household size variables are statistically significant for all food categories. However, many coefficients of price estimates are positive, which is inconsistent with the normal expectations from demand relations.[31] More insights on marginal effects of the relationships may be provided by the price and socioeconomic variable elasticities.

5.2 Computed Elasticities

The uncompensated elasticities of prices and elasticities for socioeconomic variables from selection models 1-3 are presented in Tables 5.2.1 to 5.2.6.[32] Similar to the parameter estimates, results of elasticities do not exhibit great changes across different model variations.

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31 Because expenditure forms are used in demand estimation and *expenditure =price ×quantity*, the quality effect of *price* inside expenditure may overweigh the *quantity* effect when price changes, if *quantity* change is not large. Hence, a positive coefficient on price is possible.

32 Standard errors for the calculated elasticities are listed in parentheses, and the rule applies to all later tables.

Table 5.2.1 Price Elasticities for Single Equation Applications

	1986					1992				
	FAFH	*FAH*	*COV*	*MEAL*	*SNACK*	*FAFH*	*FAH*	*COV*	*MEAL*	*SNACK*
Model 1										
FAFH	-0.3677	0.3695	0.1193	-0.0474	0.2510	-0.3839	0.1701	0.3588	0.0278	0.3259
	(0.0970)*	(0.0915)*	(0.0982)*	(0.0976)*	(0.0762)*	(0.0498)*	(0.0767)*	(0.0422)*	(0.0608)*	(0.0615)*
FAH	0.1288	-0.8217	0.1430	0.0942	0.0546	0.0987	-0.8417	0.1348	-0.0661	0.1222
	(0.069)*	(0.0241)*	(0.0717)*	(0.0117)*	(0.0072)*	(0.0851)	(0.0103)*	(0.0455)*	(0.0651)*	(0.0511)*
COV	0.0714	0.0273	-0.7279	-0.05312	0.0845	0.0298	0.0336	-0.7405	0.0922	0.0496
	(0.0707)	(0.0685)	(0.0204)*	(0.0027)*	(0.0038)*	(0.0379)	(0.0165)*	(0.0052)*	(0.0768)	(0.0208)*
MEAL	-0.0008	0.0012	-0.0009	-0.9982	0.0012	-0.0149	-0.1823	0.5093	-1.1307	0.1923
	(0.0780)	(0.0410)	(0.0381)	(0.0286)*	(0.0271)	(0.0766)	(0.0823)*	(0.0065)*	(0.0623)*	(0.0463)*
SNACK	0.0924	0.1579	0.1565	0.1373	-0.6624	0.0360	0.0940	0.2113	-0.0210	-0.1091
	(0.0518)*	(0.0611)*	(0.007)*	(0.0794)*	(0.0933)*	(0.0678)	(0.0129)*	(0.0405)*	(0.0171)*	(0.0184)*
Model2										
FAFH	-0.3649	0.3817	0.1228	0.056	0.2395	-0.4898	0.1399	0.3122	0.0664	0.3170
	(0.0549)*	(0.0033)*	(0.048)*	(0.0154)*	(0.0873)*	(0.0808)*	(0.0401)*	(0.0788)*	(0.0125)*	(0.0506)*
FAH	0.1447	-0.8001	0.1656	-0.0009	0.0580	0.1233	-0.7874	0.1778	0.1121	0.1870
	(0.0427)*	(0.0302)*	(0.0871)*	(0.0312)*	(0.0830)*	(0.0583)*	(0.0122)*	(0.0696)*	(0.032)*	(0.07405)*
COV	0.0592	0.0661	-0.7507	-0.1214	0.0718	0.0196	0.0323	-0.7702	-0.0899	0.0325
	(0.0910)	(0.0890)	(0.022)*	(0.0544)*	(0.0921)*	(0.0434)	(0.0893)	(0.0257)*	(0.0019)*	(0.0702)
MEAL	-0.0008	0.0012	-0.0013	-0.9969	0.0011	0.02317	-0.1016	0.1225	-0.1857	0.0030
	(0.0847)	(0.0445)	(0.0887)*	(0.0151)*	(0.0765)*	(0.0331)	(0.0757)*	(0.0107)*	(0.0582)*	(0.0207)
SNACK	0.097587	0.1612	0.1598	0.0356	-0.3940	0.0407	0.0640	0.2054	0.0910	-0.0452
	(0.0606)*	(0.0561)*	(0.0757)*	(0.0579)	(0.0281)*	(0.0316)*	(0.0653)	(0.0841)*	(0.03834)*	(0.0875)
Model3										
FAFH	-0.3607	0.3896	0.1272	0.0554	0.2382	-0.5421	0.1358	0.3233	0.0556	0.3122
	(0.0002)*	(0.0132)*	(0.078)*	(0.0221)*	(0.0226)*	(0.0419)*	(0.0039)	(0.0826)*	(0.0311)*	(0.0948)*
FAH	0.1484	-0.7998	0.1670	-0.0026	0.0583	0.1116	-0.7861	0.1790	0.1104	0.1832
	(0.0244)*	(0.0215)*	(0.0278)*	(0.0042)	(0.0099)*	(0.0966)*	(0.0787)	(0.0331)*	(0.0536)*	(0.001)*
COV	0.0627	0.0612	-0.7399	-0.1230	0.0748	0.0197	0.0351	-0.7630	-0.0868	0.0351
	(0.0054)	(0.0872)	(0.0990)*	(0.0564)*	(0.0436)	(0.0897)*	(0.084)	(0.0789)*	(0.055)	(0.0233)
MEAL	-0.0008	0.0011	-0.0014	-0.9961	0.0010	0.0101	-0.0911	0.1493	-0.3327	-0.0017
	(0.0383)	(0.0688)	(0.0159)	(0.0303)*	(0.0414)	(0.0370)*	(0.0763)	(0.0308)*	(0.0575)*	(0.0065)
SNACK	0.0983	0.1634	0.1616	0.0312	-0.6632	0.0376	0.0640	0.2046	0.0893	-0.0601
	(0.0541)*	(0.0782)*	(0.0274)*	(0.0037)*	(0.0716)*	(0.0967)	(0.0925)	(0.0480)*	(0.0881)	(0.0777)

Note: The rows in this table correspond to the estimated equations. *statistically significant at the 5% level.

Price elasticities for both years with three model versions are provided in Table 5.2.1. Most of the estimated elasticities are statistically significant at the 5% or 10% critical levels where insignificant estimates are found primarily as cross-price elasticities related to prepared meals. The own price elasticities of demand for all food categories in both years are negative with values between –1–0 with standard errors smaller than 0.1. This means that the five food categories are not very own-price elastic. The reason for this reflects the 'necessity' nature of food and may also reflect the aggregate nature of the groups. Food-away-from-home (FAFH) is an inelastic (–0.3587 to -0.3649 for 1986 and -0.3840 to -0.5421 for 1992) food category with respect to its own price. A one percent increase in FAFH price will only cause a 0.35% to 0.54% reduction in FAFH expenditure. This result indicates that FAFH consumption is not strongly affected by price changes. Food at home (FAH) expenditure is relatively more own-price but still has an absolute value less than unity. These elasticities range from -0.79 to -0.82 for 1986 and -0.78 to -0.84 for 1992, implying that a slight increase in FAH price will cause a relatively larger reduction in expenditure than for FAFH. Convenience food (COV) has own price elasticities estimates ranging from -0.72 to -0.75 for 1986 and -0.74 to -0.77 for 1992. The prepared meals is the most own-price elastic category (-0.9961—0.9969 for 1986 and less than –1 for 1992). Although still less than one in absolute values, the consumption of prepared meals is more price-sensitive than any other food category. Own price elasticity estimates of snacks ranges from -0.39 to -0.66 for 1986 and -0.04 to -0.11 for 1992. The snack consumption exhibits the most inelastic response with respect to its own price for 1992. The general results of own price elasticities for both years data indicate that $\varepsilon_{meal} > \varepsilon_{fah} > \varepsilon_{cov} > \varepsilon_{fafh} > \varepsilon_{snk}$.

The cross price elasticity estimates between most food categories are positive, implying that these food categories are basically substitutes. Food-away-from-home is a substitute for all types of food in both 1986 and 1992, with only one exception (Model 1 for 1986). Negative cross price elasticities indicate that prepared meals are a complement to FAFH (1986,1992) and FAH (1992), COV (1986); Convenience food are also complements to prepared meal (1986,1992). Like the estimated parameters and own price elasticities, the results from different models do not present much variation.

Table 5.2.2 Elasticities of Social-demographic Variables for FAFH

	1986			*1992*		
	model 1	*model 2*	*Model 3*	*model 1*	*model2*	*model3*
AGE	-0.3176	-0.319664	-0.320224	-0.123795	-0.113798	-0.12001
	(0.000708)*	(0.005321)*	(0.005732)*	(0.000711)*	(0.004078)*	(0.007057)*
NFEARNER	0.099811	0.099821	0.099923	0.15246	0.152566	0.153521
	(0.005412)*	(0.008385)*	(0.006839)*	(0.006768)*	(0.001226)*	(0.008126)*
INCOME	0.541064	0.54329	0.543847	0.46295	0.45479	0.461862
	(0.003213)*	(0.00273)*	(0.002359)*	(0.003445)*	(0.000457)*	(0.008364)*
HSIZE	0.009062	0.008663	0.009079	0.085499	0.087559	0.087564
	(0.000243)*	(0.00206)*	(0.006186)	(0.002353)*	(0.002776)*	(0.001675)*
ARRIVAL	-0.003151	-0.003304	-0.003367	-0.104845	-0.106586	-0.1093
	(0.002389)*	(0.005296)	(0.001087)*	(0.005684)*	(0.006864)*	(0.003952)*

*statistically significant at the 5% critical level.

Table 5.2.2 provides the elasticities with respect to continuous socioeconomic variables for food-away-from-home. Elasticities for dummy index variables are not provided since their interpretation is not obviously useful. Most of the elasticities are statistically significant at 5% or 10% critical levels. The elasticity of FAFH with respect to the age of the household head is negative, suggesting that younger persons are major consumers of FAFH. The negative elasticities of FAFH with respect to the number of children show that the more children there are in a family, the less the consumption of the FAFH. Elasticity of the number of full time earners (NFEARNER) is positive, indicating that the more full-time workers in a household, the greater the expenditure on FAFH. Income elasticities (INCOME) are positive and are the relatively most elastic ones among elasticities with respect to all the social-demographic variables. This ranges from 0.4548 to 0.5438, which means that a one percent increase in total income before tax will result in a 0.45% to 0.54% expansion in FAFH consumption. FAFH is more income elastic in 1986 than 1992. Income and own price elasticities demonstrated that FAFH expenditures are more sensitive to the household income than to its own price.

Table 5.2.3 Elasticities of Social-demographic Variables for FAH

	1986			*1992*		
	model1	*model2*	*Model3*	*model1*	*model2*	*model3*
AGE	0.254031	0.255237	0.25047	0.268074	0.170242	0.168381
	(0.001989)*	(0.003399)*	(0.002278)*	(0.000882)*	(0.008161)*	(0.002635)*
NFEARNER	-0.003345	-0.003256	-0.003577	0.020481	0.021972	0.022041
	(0.008031)*	(0.008753)*	(0.004836)	(0.004715)*	(0.00263)*	(0.000864)*
INCOME	0.128263	0.127433	0.129508	0.121242	0.135727	0.1368
	(0.009999)*	(0.001061)*	(0.008918)*	(0.005154)*	(0.000335)*	(0.002236)*
HSIZE	0.530301	0.53077	0.528293	0.490611	0.424028	0.422708
	(0.008659)*	(0.004544)*	(0.0076)*	(0.009825)*	(0.004809)*	(0.001061)*
ARRIVAL	0.01621	0.016192	0.016249	0.04975	0.057845	0.057881
	(0.009327)*	(0.007251)*	(0.001311)*	(0.00352)*	(0.009987)*	(0.002106)*

*statistically significant at the 5% critical level.

Table 5.2.3 provides the elasticities with respect to socio-demographic variables for food-at-home. All of them are statistically significant at 5%-10% critical levels. The positive elasticities for the age variable indicate that FAH consumption increases with an increase in the age of the household head. Income elasticity estimates (INCOME) are positive and range from 0.1282 to 0.1368, which means that a one percent increase in total income before tax will result in a 0.128% to 0.136% expansion in FAH consumption. The total household size variable is significant in parameter estimation and has elasticities ranging from 0.42 to 0.53, which is relatively more elastic than other social-demographic variables. This indicates that the larger the household size, the more food consumption is allocated to FAH. Immigrant arrival year is also significant, with elasticities ranging from 0.016 to 0.057, implying that the later the immigrant comes to Canada, the more FAH is preferred.

Table 5.2.4 Elasticities of Social-demographic Variables for COV

	1986			1992		
	model 1	*model 2*	*model3*	*model 1*	*model 2*	*model3*
AGE	0.107276	0.109854	0.100743	0.119714	0.138624	0.133079
	(0.00323)*	(0.004711)*	(0.007411)*	(0.000704)*	(0.005985)*	(0.008252)*
NFEARNER	-0.03575	-0.035729	-0.035711	-0.014923	-0.006353	-0.007878
	(0.004114)*	(0.006636)*	(0.000765)*	(0.007553)*	(0.000409)*	(0.007789)*
INCOME	0.073931	0.073186	0.075915	0.072606	0.076496	0.075977
	(0.006069)*	(0.005123)*	(0.000321)*	(0.004463)*	(0.008476)*	(0.007)*
HSIZE	0.653391	0.653609	0.652096	0.606661	0.617365	0.613762
	(0.000892)*	(0.003042)*	(0.000847)*	(0.004249)*	(0.008435)*	(0.0033)*
ARRIVAL	-0.007161	-0.007199	-0.007089	0.006843	0.005008	0.005891
	(0.003965)*	(0.00546)	(0.003685)*	(0.009427)*	(0.000604)*	(0.003894)*

*statistically significant at the 5% critical level.

Table 5.2.4 provides the elasticities with respect to socio-demographic variables for convenience food. Most are statistically significant at a 5% or 10% critical level. The positive elasticities for age variables indicate that COV expenditure increases with the increased age of the household head. Income elasticities (INCOME) are positive, ranging from 0. 073 to 0.076, which means that a one percent increase in total income before tax will result in a 7.3% to 7.6% expansion in COV consumption. This is inelastic compared to the income elasticity of FAFH and FAH. The total household size variable is significant in parameter estimation and has elasticities ranging from 0.60 to 0.65, which is the most elastic estimate of all the social-demographic variables. This indicates that households with more members tend to spend more on convenience food.

Table 5.2.5 Elasticities of Social-demographic Variables for MEAL

	1986			1992		
	model 1	*model 2*	*model 3*	*model 1*	*model 2*	*model 3*
AGE	0.000793	0.000792	0.000761	-0.018024*	-0.000589	0.001355
	(0.003395)	(0.008396)	(0.006923)	(0.002293)	(0.009634)	(0.005213)
NFEARNER	0.000331	0.000331	0.00033	-0.116272*	0.071225*	0.07366*
	(0.003094)	(0.009373)	(0.006609)	(0.006056)	(0.003223)	(0.00496)
INCOME	-0.000221	-0.00022	-0.000172	0.127712*	-0.05835*	-0.048444*
	(0.007141)	(0.005969)	(0.000874)	(0.005407)	(0.00444)	(0.002402)
HSIZE	-0.001804	-0.001804	-0.001957	-0.136246*	0.049312*	0.056798*
	(0.008017)	(0.006923)	(0.00826)	(0.003303)	(0.007872)	(0.005137)
ARRIVAL	-0.000269	-0.000269	-0.000258	0.167187*	0.040379*	0.042517*
	(0.001547)	(0.000808)	(0.001276)	(0.006189)	(0.008397)	(0.009187)

*Statistically significant at 5% critical level.

Elasticities of social-demographic variables for prepared meals are provided in Table 5.2.5. Most of the elasticities are statistically insignificant, consistent with the insignificance of most of the estimated coefficients. Due to the insignificance of the prepared meal equation, a discussion on elasticities for this is omitted.

Table 5.2.6 Elasticities of Social-demographic Variables for Snacks

	1986			*1992*		
	Model 1	*model 2*	*model 3*	*model 1*	*model 2*	*model 3*
AGE	1.76E-01	1.75E-01	1.75E-01	3.47E-01	3.24E-01	0.323683
	(0.004886)	(0.003116)	(0.001175)	(0.000511)	(0.008285)	(0.008078)
NFEARNER	-0.026395	-0.026385	-0.026533	-0.02496	-0.023656	-0.023834
	(8.19E-05)	(0.007821)	(0.005242)	(0.006319)	(0.001816)	(0.003091)
INCOME	1.57E-01	1.57E-01	1.57E-01	0.124026	0.123072	0.124026
	(0.007127)	(0.002713)	(0.004607)	(0.00856)	(0.005604)	(0.007326)
HSIZE	0.409928	0.409161	0.408711	0.477144	0.452814	0.004869
	(0.007654)	(0.004767)	(0.000878)	(0.002475)	(0.004445)	(0.005436)
ARRIVAL	0.026417	0.02644	0.026428	0.038932	0.040897	0.452315
	(0.006775)	(0.001946)	(0.000503)	(0.007867)	(0.000368)	(0.006049)

*All elasticities in this table are statistically significant at 5% critical level.

Table 5.2.6 presents the elasticities of socio-demographic variables for snacks. All elasticities are statistically significant at a 5% to 10% critical level. The positive elasticities with respect to the age variables indicate an increase in snack consumption with older household heads. Income elasticities (INCOME) range from 0.1230 to 0.1570, indicating that a one percent increase in total income before tax will result in a 12.30% to 15.70% expansion in snack consumption. As usual, the total household size variable is significant and has elasticities around 40% to 50%, which is the most elastic of all the socio-demographic variables. This demonstrates again that food consumption is related to the household size. The immigrant arrival year is also significant and has elasticities ranging from 0.026 to 0.45, implying that the later the immigrant comes to Canada, the more snack expenditure occurs.

The general nature of elasticities with respect to socioeconomic and demographic variables demonstrates that the elasticities of household size for most of the food categories are positive except that of the FAFH for 1992. This is the largest elasticity that is even greater than income elasticity. The household size elasticity for convenience food is the most elastic category (0.6531–0.6536 for 1986, 0.6067–0.6173 for 1992) among all food categories. Income elasticities (INCOME) for all food categories are positive. Food-away-from-home is the most income elastic one (0.5411–0.5438 for 1986, 0.4619–0.4630 for 1992), and convenience foods constitute the most inelastic one (0.0732–0.0759 for 1986, 0.0726–0.0765 for 1992).

5.3 Comparison with Elasticities from Previous Studies

The results of single equation estimations generally conform to the finding of previous studies with a few exceptions. The major determinants of FAFH consumption include income and the number of full-time earners. This is consistent with, and enriches McCracken and Brandt's (1987) result that income is the major determinant of FAFH. Our results also closely conform to Horton and Campbell (1991) and Reynolds and Goddard's (1993) study using FFES 84 and 86 data. Factors such as the gender of the household head, marital status, presence of children, education level and region of residence have strong effects on Canadian households' consumption on FAFH, similar to the previous studies for Canadian and US households (Horton and Campbell 1991; Reynolds and Goddard 1993; Prochaska and Schrimper 1973; Kinsey 1983; McCracken and Brandt 1987; Lee and Brown 1986; Yen 1993; Nayga and Capps 1992). The estimated coefficients in our study closely resemble the results of Reynolds and Goddard (1993). As in their studies, the *urban* variable does not exhibit a strong effect on FAFH consumption in single equation demand estimation.[33]

The estimated income elasticities for FAFH in this study (0.45–0.54) are higher than those of US studies (0.11–0.36, see Table 2.1.1), but they are consistent with Reynolds and Goddard's (1993) finding (0.5982) using FFES 86 data. The results imply that Canadians are slightly more sensitive to income changes than Americans with respect to FAFH consumption. The household size elasticities for FAFH from single equation results in our study (0.008-0.085) are much smaller than those of US studies (0.27-0.32, see Table 2.1.1) and are also different from Reynolds and Goddard's (1993) result (-0.2905). The smaller elasticities and the insignificant and negative coefficients for household size imply that this variable is not an important determinant for Canadians' decisions to eat out. A further comparison of household size elasticities for FAFH will be made after demand system estimations in Chapter 6.

33 The *Urban* variable has different estimation results in demand system, which will be discussed in Chapter 6.

As for the FAH results, the estimated own-price elasticity estimates are from –0.78 to –0.84, which is relatively more elastic than Capps et al's (1985) estimation (-0.22) on non-convenience food. This may be a consequence of the study of Capps et al's (1985) including snacks in the non-convenience food category, which made the category wider and less sensitive to price changes. The income elasticities for FAH in our study are 0.1212-0.1368, close to Nayga's (1996) result (0.11). This suggests that household income has a similar role in FAH consumption for both Canadians and Americans.

The estimated own price elasticities for convenience food in our studies are –0.75 for 1986 and –0.77 for 1992, which are also close to Capps et al's (1985) study (-0.8491). The income elasticities for convenience food in our study range from 0.073 to 0.076, much smaller than Capps et al's (1985) result (0.2785 to 0.3403). This may be partially due to the discrepancy in the classification of convenience food[34] and partially due to different consumption behavior of Canadians and Americans.

The own price elasticities for prepared meals in our studies are around –0.18 to –1.0 across different models, with a wider range than those of Park and Capps' (1997) study (-0.23 to –0.65). Income elasticities for prepared meals in our study are negative and insignificant; hence, comparison with Park and Capps' (1997) study (0.07 to 0.13) is not appropriate. A comparison of snack elasticities is not provided due to the lack of previous studies.

5.4 Sub-Sample Estimation Results

The unitary estimation approach outlined above provides general information about household demand for foods. To explore the intra-household allocation of demand by different family members, a collective setting gives one approach. However, due to the limitation of FFES data, specifically lack of income information for separate household members, a collective model is difficult to model. For this reason, we chose to investigate the postulated variation in household member decisions on food consumption by dividing the whole data sample into several sub-samples, according to the socio-demographic characteristics of female household members. Details of intra-household effects along these lines will be assessed by conducting model tests on structural change and

34 Capps et al (1985) included prepared meals in the convenience food category.

comparison of price and income elasticities. The sub-samples classified by the characteristics of female household members are selected as our research target because the "working wife" dummy variable in the unitary approach is not statistically significant. A further decomposition of the variable may better reveal the effects of female household member's marital and employment status on food demand. The number of observations in each sub-sample is provided in Table 5.4.1.

Table 5.4.1 Sub-Sample Categories and Number of Observations

Sub-sample Categories	*Sample Size*	
	1986	1992
Household with children and not employed single woman	22	39
Household with children and part-time employed single woman	27	24
Household with children and full-time employed single woman	11	41
Household with not employed single woman, no children	144	129
Household with part-time employed single woman, no children	211	171
Household with full-time employed single woman, no children	366	342
Household with children and not employed married woman	77	336
Household with children and part-time employed married woman	288	429
Household with children and full-time employed single woman	746	223
Household with not employed married woman, no children	2236	3361
Household with part-time employed married woman, no children	1609	2168
Household with full-time employed married woman, no children	4698	2865

Table 5.4.1 indicates that the three sub-samples of *households with a single woman and children* are very small based on the FFES data. It is difficult to estimate the demand function with such few numbers due to the need for sufficient degrees of freedom, even after pooling the three samples of *households with a single woman and children* together. Hence, estimations of this category for both years are omitted, with only the exception of *household with not employed single woman and children* category for 1992. A single equation model is estimated for all other sub-samples by adopting estimation model 1 because it is considered theoretically more appropriate and an empirically better fit for the data. The estimated price and income elasticities for different sub-samples are provided in Table 5.4.2-5.4.4. The Chow (1960) test results of structural change indicate that the F statistics for every two different sub-samples are between 1.74 and 3.95, which is greater than the critical value $F(30,100)=1.57$ and $F(30, 3457)\approx 1.46$. The result rejected the hypothesis that the coefficients of different sub-sample estimations are identical. This implies that the female household members with different characteristics have different impacts on household expenditure for food, otherwise the

estimates from various sub-samples should be similar. Hence, intra-household allocations of decision for demand with regard to various family members do exist. To further interpret and compare food demand for different types of households, the price and income elasticities for sub-sample groups are calculated and provided in Table 5.4.2. Elasticities for other variables are not listed but can be retrieved upon request.

Table 5.4.2 Elasticities for Households with a Married Woman and Children

	Households with children and a full-time employed married woman						
		FAFH	FAH	COV	MEAL	SNK	Income
	FAFH	-0.697063	0.507032	0.43741	-0.093823	-0.352258	1.01657
		(0.047947)*	(0.020292)*	(0.061014)*	(0.023382)*	(0.067668)*	(0.043168)*
	FAH	7.33E-02	-0.929256	0.419636	0.210339	-0.400771	0.076802
		(0.025008)*	(0.010889)*	(0.063698)*	(0.066361)*	(0.024904)*	(0.049019)*
1986	COV	-5.52E-02	-0.332793	-1.10218	0.389485	-0.662526	-0.021312
		(0.077123)	(0.01652)*	(0.002153)*	(0.056449)*	(0.027065)*	(0.055095)
	MEAL	-1.14E-03	0.000155	0.009664	-1.00083	-4.20E-05	-0.000759
		(0.007023)	(0.064532)	(0.014291)	(0.003326)*	(0.050107)	(0.078539)
	SNK	-2.21E-01	0.598837	0.465347	1.3249	-1.66418	0.236466
		(0.014586)*	(0.052299)*	(0.080491)*	(0.048502)*	(0.007499)*	(0.027418)*
	FAFH	-0.320615	-0.149235	0.715179	0.190056	0.220383	0.407702
		(0.015204)	(0.003784)	(0.066868)	(0.083645)	(0.044535)	(0.043614)
	FAH	0.095519	-0.806766	0.285223	0.024328	-0.033854*	0.142476
		(0.028283)*	(0.00297)*	(0.036444)*	(0.046482)*	(0.045521)*	(0.073682)*
1992	COV	-0.082856	0.140432	-0.795983	-0.154306	-0.163524	-0.002832
		(0.053194)*	(0.03753)*	(0.084348)*	(0.046203)*	(0.029914)*	(0.043824)*
	MEAL	0.112257	-0.592792	0.279987	-0.693544	-0.384449	-0.090062
		(0.079455)	(0.065923)*	(0.029678)*	(0.065478)*	(0.028074)*	(0.033266)*
	SNK	0.029089	0.099553	0.28184	0.064318	-0.776391	0.131346
		(0.070134)	(0.030897)*	(0.065267*	(0.065674)*	(0.077743)*	(0.045029)*
	Households with children and a part-time employed married woman						
		FAFH	FAH	COV	MEAL	SNK	Income
	FAFH	-0.565308	0.552888	0.349137	0.214616	-0.101072	0.209331
		(0.066708)*	(0.062962)*	(0.002671)*	(0.087011)*	(0.042812)*	(0.056865)*
	FAH	0.082662	-0.592732	-0.094883	-0.358194	0.086134	-0.008799*
		(0.056106)*	(0.02537)*	(0.008028)*	(0.069838)*	(0.01464)*	(0.014671)*
1986	COV	0.041095	0.196851	-0.737265	0.144064	-0.778474	0.024931
		(0.030323)	(0.007277)*	(0.049979)*	(0.033049)*	(0.004776)*	(0.086699)*
	MEAL	-0.002725	-0.011099	-0.002107	-0.999622	0.001172	-0.001338
		(0.022395)	(0.040579)	(0.060357)	(0.012953)*	(0.082989)	(0.06519)
	SNK	0.137241	0.922113	0.340572	-0.097754	-1.09925	0.780619
		(0.017545)*	(0.006387)*	(0.045297)*	(0.00562)*	(0.062965)*	(0.060395)*
	FAFH	-0.559162	0.144069	0.332036	0.058165	0.133015	0.406665
		(0.002387)*	(0.074589)*	(0.011687)*	(0.032906)*	(0.025068)*	(0.082473)*
	FAH	0.099515	-0.768519	0.072471	0.079633	-0.053626	0.136644
		(0.019982)*	(0.008798)*	(0.05239)	(0.087428)	(0.039907)	(0.082112)*
1992	COV	0.034221	0.078467	-0.781132	-0.101113	0.095561	0.085726
		(0.076346)	(0.004776)*	(0.022494)*	(0.014863)*	(0.002547)*	(0.018729)*
	MEAL	-0.022789	0.423647	-0.464341	-0.674104	0.338364	-0.012796
		(0.081429)*	(0.005734)*	(0.07475)*	(0.077799)*	(0.04272)*	(0.079583)*

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	SNK	0.092271	0.03883	0.482068	-0.232142	-0.780818	0.068949
		(0.055925)*	(0.049242)	(0.01407)*	(0.079158)*	(0.040704)*	(0.054794)
		Households with children and a not employed married woman					
		FAFH	FAH	COV	MEAL	SNK	Income
	FAFH	-0.498874	-0.197501	-0.235097	0.119207	-0.030507*	0.882803
		(0.062885)*	(0.001196)*	(0.060701)*	(0.020367)*	(0.067154)*	(0.007327)*
	FAH	0.112631	-1.58408	0.438355	-0.428677	-0.070536	0.167466
		(0.005578)*	(0.014194)*	(0.082311)*	(0.011718)*	(0.038653)*	(0.046143)*
1986	COV	0.259636	-0.422468	-1.32202	0.12942	0.375151	0.104771
		(0.063484)*	(0.082646)*	(0.037387)*	(0.029409)*	(0.076035)*	(0.010059)*
	MEAL	N/A	N/A	N/A	N/A	N/A	N/A
	SNK	0.096902	0.388932*	0.532596	-0.273124	-0.797232	0.226935
		(0.02071)*	(0.012843)	(0.063638)*	(0.047319)*	(0.064722)*	(0.077772)*
	FAFH	-0.484054	0.333765	0.252848	-0.184665	0.440029	0.604571
		(0.080346)*	(0.071871)*	(0.084901)*	(0.067016)*	(0.015755)*	(0.039339)*
	FAH	0.085171	-0.956676	0.052273	-0.189519	0.148153	0.32764
		(0.088768)*	(0.070451)*	(0.001517)*	(0.070508)*	(0.014671)*	(0.012399)*
1992	COV	-0.002912	0.109094	-0.913097	-0.239505	0.00733	0.49764
		(0.039516)*	(0.025962)*	(0.024327)*	(0.076807)*	(0.045686)*	(0.047498)*
	MEAL	-0.053485	0.802601	1.67255	-1.00628	-0.230501	-0.075355
		(0.078724)	(0.068627)*	(0.088871)*	(0.005033)*	(0.039888)*	(0.077735)*
	SNK	0.108324	0.138059	0.032279	-0.254068	-0.801256	0.506518
		(0.072716)	(0.009302)*	(0.023334)	(0.044906)*	(0.043333)*	(0.068574)*

*statistically significant at the 5% critical level.

Table 5.4.2 provides the price and income elasticities for households with a married woman and children sub-samples. Food-away-from-home is the most inelastic category for all employment statues in both years. In general, the married woman with children and stay at home category exhibits relatively small FAFH price elasticities, but relatively large elasticities with respect to the food-at-home price changes. This result implies that women who stay at home with children tend to cook for their families rather than eat out. The subgroup of women with children and working full time exhibits higher price elasticities on FAFH, FAH and snacks than those who work part-time. Convenience foods and prepared meals are the most price-elastic food categories, and there is not much variation across employment status. The results imply that households with married woman and children are quite sensitive to price changes for these two food choices. Income elasticities are relatively similar for the category of households that include women who work and with children, while households with women who stay at home have higher elasticities and are more sensitive to income changes. Like the general results for the whole FFES data sample, the income elasticity for FAFH is the highest among food categories, which indicates that eating out is very sensitive to the income level of the household.

Table 5.4.3 Elasticities for Households with a Married Woman, No Children

		FAFH	FAH	COV	MEAL	SNK	Income
Household with a full time employed married woman, no children							
	FAFH	0.02753	0.365561	0.1324	0.175397	0.344878	0.608903
		(0.032359)	(0.017413)*	(0.059768)*	(0.075571)*	(0.044305)*	(0.057479)*
	FAH	0.05964	-0.851285	0.202406	-0.096885	0.031624	0.135168
		(0.026212)*	(0.016047)*	(0.04582)*	(0.054547)*	(0.018927)*	(0.035593)*
1986	COV	0.091783	0.083196	-0.62557	-0.137626	0.120514	0.128764
		(0.065616)*	(0.073665)	(0.043883)*	(0.031004)*	(0.011731)*	(0.067089)*
	MEAL	-0.000451	-0.002253	-0.00085	-0.99762	0.001244	0.000337
		(0.015859)	(0.04078)	(0.084174)	(0.018738)*	(0.046168)	(0.073746)
	SNK	0.005533	0.284243	0.197994	-0.098739	-0.601021	0.182963
		(0.050653)*	(0.07425)*	(0.016354)*	(0.041962)*	(0.012273)*	(0.036381)*
	FAFH	-0.434165	0.439424	0.417785	-0.115873	0.261939	0.417736
		(0.028493)*	(0.079536)*	(0.008135)*	(0.01172)*	(0.019244)*	(0.060098)*
	FAH	-0.132445	-0.938656	-0.106245	-0.07117	0.159553	0.110998
		(0.008124)*	(0.072514)*	(0.066353)	(0.081821)*	(0.060177)*	(0.027386)*
1992	COV	0.002298	0.043512	-0.720622	0.101237	0.188024	0.090449
		(0.045977)*	(0.052302)	(0.038382)*	(0.065616)*	(0.00839)*	(0.08527)*
	MEAL	0.252968	0.013291	-0.145	-0.165522	0.03932	0.241505
		(0.03023)*	(0.064736)*	(0.079466)*	(0.057025)*	(0.025297)*	(0.065395)*
	SNK	0.03146	0.138825	0.139976	0.072308	-0.711877	0.146642
		(0.05838)	(0.041975)*	(0.073113)*	(0.030082)*	(0.054775)	(0.015344)*
Households with a part time employed married woman, no children							
		FAFH	FAH	COV	MEAL	SNK	Income
	FAFH	-0.731855*	0.312126*	0.43501*	0.081384*	-0.168968*	0.394157*
		(0.014479)	(0.018822)	(0.003336)	(0.0196)	(0.037041)	(0.062812)
	FAH	0.003816	-1.00553	0.042737	-0.043215	-0.067504	0.089868*
		(0.050517)	(0.088024)	(0.070433)	(0.059315)	(0.072153)	(0.04962)
1986	COV	-0.133337*	-0.038604	-0.940998*	-0.000101	-0.148306*	0.037072*
		(0.003394)	(0.057659)	(0.081839)	(0.048173)	(0.035724)	(0.019943)
	MEAL	0.00307	0.000269	0.007175	-1.00128*	0.001017	0.000126
		(0.061463)	(0.020431)	(0.057715)	(0.042131)	(0.06394)	(0.022731)
	SNK	0.323136*	0.126332*	0.076278*	0.096862	-0.962554*	0.157442*
		(0.069913)	(0.050297)	(0.056426)	(0.054429)	(0.074296)	(0.029477)
	FAFH	-0.435958	0.045703	0.361312	0.072005	0.347427	0.600352
		(0.021738)*	(0.082935)	(0.052324)*	(0.039702)*	(0.008296)*	(0.032944)*
	FAH	0.047063	-0.80764	-0.273313	-0.230594	-0.020524	0.255332
		(0.086602)	(0.085947)*	(0.080165)*	(0.055256)*	(0.01407)	(0.053554)*
1992	COV	0.036878	0.07156	-0.929108	-0.225409	0.116351	0.1241.72
		(0.025855)	(0.043227)	(0.003063)*	(0.082915)	(0.06728)	(0.086293)
	MEAL	-0.121435	0.824685	0.317863	-0.510596	-0.64683	0.5478.05
		(0.088394)*	(0.020901)*	(0.045087)*	(0.059019)*	(0.060358)*	(0.079328)*
	SNK	0.10909	0.30714	-0.002746	-0.24663	-0.723729	0.212833
		(0.050271)*	(0.028696)*	(0.086161)	(0.007036)*	(0.036252)*	(0.08004)*
Households with a not employed married woman, no children							
		FAFH	FAH	COV	MEAL	SNK	Income
	FAFH	-0.487719	0.256798	0.073187	-0.234951	0.327893	0.303255
		(0.045277)*	(0.009084)*	(0.000824)*	(0.080422)*	(0.078203)*	(0.035315)*

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	FAH	0.078313	-1.04629	0.072496	0.015807	0.057971	0.259391
		(0.0807)*	(0.0106)*	(0.073339)*	(0.014805)	(0.038828)	(0.053529)*
1986	COV	0.033483	0.174595	-0.952938	-0.216651	0.116354	0.098054
		(0.073957)	(0.013907)*	(0.014754)*	(0.087131)*	(0.017822)*	(0.052299)
	MEAL	-0.002362	0.00723	-0.002162	-0.999324	0.000816	-0.00258
		(0.026964)	(0.008001)	(0.057302)	(0.089903)	(0.073549)	(0.035681)
	SNK	0.060262	0.061072	-0.062253	-0.051935	-0.763205	0.256419
		(0.075266)*	(0.001298)*	(0.02157)*	(0.018411)*	(0.050155)*	(0.045044)*
	FAFH	-0.179379	0.28944	0.239269	0.1706	0.431453	0.379463
		(0.029318)*	(0.057505)*	(0.058654)*	(0.01682)*	(0.040432)*	(0.026725)*
	FAH	0.022725	-0.92259	0.107795	-0.097243	0.058368	0.125132
		(0.022599)*	(0.06896)*	(0.088484)*	(0.020122)*	(0.044482)*	(0.075129)*
1992	COV	-0.080213	-0.204265	-0.862887	-0.266547	-0.061096	0.115835
		(0.076544)	(0.025766)*	(0.088406)*	(0.076884)*	(0.014778)*	(0.068354)
	MEAL	-0.175909	-0.434777	0.112722	-0.63695	0.629988	0.116048
		(0.056685)*	(0.014895)*	(0.015817)*	(0.070618)*	(0.046467)*	(0.050368)*
	SNK	0.01267	0.124106	0.190495	-0.189154	-0.71331	0.185204
		(0.05836)	(0.0348)*	(0.04771)*	(0.013694)*	(0.022928)*	(0.068557)*

*statistically significant at the 5% critical level.

Table 5.4.3 provides the price and income elasticities for households with a married woman and without children. Food-away-from-home is the most inelastic food category with respect to price. All other food categories are relatively more elastic, with elasticities approaching minus one. For most samples, FAH and COV consumption data indicate that the food consumption of *households with a full-time employed married woman, no children* category is less price-elastic than that of *households with a part-time employed married woman, no children* category. The latter is even more inelastic than consumption of *households with an unemployed married woman, no children* category. This phenomenon suggests that the household consumption of FAH and COV is sensitive to the employment status of the married, no children woman. The income elasticities for food-away-from home are still the highest among all food categories.

Table 5.4.4 provides the price and income elasticities for sub-samples of households of single women. For all single woman categories, FAFH is still the most inelastic category among all foods. Elasticities for other food categories vary across different foods and sub-samples; however, no major differences in values are exhibited. Compared with the sub-samples of households with married women, we find that although discrepancies across price elasticities between the sub-samples of households with married women and single women are not particularly large, the price elasticities for households with single women are generally larger. The income elasticities again demonstrate that FAFH is the most elastic category. Moreover, almost half of the income elasticities for single women samples are much smaller than those of the married women. This implies that food consumption of single women families is less sensitive to income changes.

Table 5.4.4 Elasticities for Households with a Single Woman

	Households with a full time employed single woman, no children					
	FAFH	FAH	COV	MEAL	SNK	Income
FAFH	-0.47052	0.257699	0.359899	-0.016514	0.079313	0.511743
	(0.00125)*	(0.009721)*	(0.021901)*	(0.081029)	(0.010994)*	(0.077334)*
FAH	0.148471	-0.819435	-0.120622	0.066579	-0.00521	0.04538
	(0.035416)*	(0.084199)*	(0.064083)*	(0.000778)*	(0.053048)*	(0.092865)
1986 COV	0.016462	-0.330418	-0.90615	-0.047733	0.141535	-0.039656
	(0.016736)*	(0.015951)*	(0.081972)*	(0.079963)	(0.029377)*	(0.078931)
MEAL	-0.002071	-0.008084	0.006812	-1.00527	-0.005886	-0.0045
	(0.066405)	(0.097255)	(0.077709)	(0.013925)*	(0.097678)	(0.04426)
SNK	0.092281	0.080716	-0.123538	-0.197383	-0.75612	0.156411
	(0.04442)*	(0.009543)*	(0.03692)*	(0.077092)*	(0.080894)*	(0.081871)*
FAFH	-0.53401	0.778757	0.371965	-0.135769	-0.108849	0.3566
	(0.039228)*	(0.041627)*	(0.073396)*	(0.087807)*	(0.056956)*	(0.016183)*
FAH	0.003226	-0.931846	0.015667	0.028161	0.260222	0.184
	(0.059413)*	(0.045111)*	(0.073926)*	(0.032029)*	(0.085237)*	(0.069989)*
1992 COV	-0.064254	-0.219759	-0.692482	-0.144151	0.273798	0.242928
	(0.078327)*	(0.036876)*	(0.040222)*	(0.032972)*	(0.096213)*	(0.005241)*
MEAL	-0.278565	-0.236468	0.12809	-0.832561	-0.234617	0.137628
	(0.0895)*	(0.096474)*	(0.06829)*	(0.088122)*	(0.085202)*	(0.056874)*
SNK	0.071703	0.028138	0.113884	-0.026967	-0.545404	0.298156
	(0.068388)	(0.072543)	(0.028852)	(0.038795)	(0.054212)	(0.092723)
	Households with a part time employed single woman, no children					
	FAFH	FAH	COV	MEAL	SNK	Income
FAFH	-0.773367	0.21174	-0.171359	-0.332741	0.156761	0.179414
	(0.099753)*	(0.050237)*	(0.015409)*	(0.058425)*	(0.09813)*	(0.043211)*
FAH	-0.195398	-0.952399	-0.02472	-0.722885	-0.086059	0.136754
	(0.070504)*	(0.053554)*	(0.047595)	(0.042371)*	(0.084321)*	(0.036612)*
1986 COV	-0.05464	-0.072282	-0.888019	-0.163361	0.055208	0.050715
	(0.09934)	(0.057385)*	(0.084995)*	(0.086658)*	(0.012022)*	(0.013063)*
MEAL	-0.020431	0.029855	-0.017312	-0.994641	0.024289	0.00092
	(0.06708)	(0.005921)*	(0.075032)	(0.015452)*	(0.006567)*	(0.06826)
SNK	-0.278889	0.235239	-0.243209	-1.31883	-0.817028	0.387453
	(0.03883)*	(0.070198)*	(0.010472)*	(0.066428)*	(0.058705)*	(0.021998)*
FAFH	-0.339441	0.846134	0.010294	0.747887	0.685957	1.02E-05
	(0.00336)*	(0.080448)*	(0.010942)*	(0.025302)*	(0.071582)*	(0.019178)*
FAH	-0.227182	-1.08209	0.237066	0.037999	-0.17641	1.54E-05
	(0.005875)*	(0.099214)*	(0.096118)*	(0.012033)*	(0.049088)*	(0.092855)*
1992 COV	0.31757	-0.037555	-0.855007	0.13504	-0.483064	1.89E-06
	(0.060887)*	(0.046761)*	(0.024939)*	(0.059475)*	(0.036568)*	(0.002792)*
MEAL	0.002666	0.494085	2.90813	-3.35007	2.39945	-1.69E-05
	(0.059289)	(0.052422)*	(0.076156)*	(0.066017)*	(0.024208)*	(0.082354)*
SNK	0.209391	0.036731	-0.100464	0.111638	-1.06318	1.14E-05
	(0.070406)*	(0.074488)*	(0.081861)*	(0.05834)*	(0.040173)*	(0.090135)*

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		FAFH	FAH	COV	MEAL	SNK	Income
		Households with a not employed single woman, no children					
		FAFH	FAH	COV	MEAL	SNK	Income
	FAFH	-0.448077*	-0.865069*	-0.822994	*0.229706	0.657384	0.15682
		(0.080376)	(0.002154)	(0.066152)	(0.023913)	(0.076306)	(0.080242)*
	FAH	-0.299115*	-0.9495*	0.170434	-*0.108846	-0.22619	0.249102
		(0.08684)	(0.068961)	(0.050336)	(0.059773)	(0.084293)	(0.048454)*
1986	COV	0.042509*	-0.150626*	-0.714908	*0.405584	-0.054479	0.088399
		(0.070342)	(0.05111)	(0.046607)	(0.076247)	(0.066842)	(0.028576)*
	MEAL	N/A	N/A	N/A	N/A	N/A	N/A
	SNK	-0.186232	0.136971	-0.283846	-0.199194	-1.09807	0.210033
		(0.046224)*	(0.005124)	(0.078045)	(0.001126)	(0.089632)	(0.001137)
	FAFH	1.62042	0.89136	0.182871	0.211304	-0.503859	3.89E-05
		(0.02803)*	(0.015539)*	(0.027899)*	(0.051431)*	(0.011794)*	(0.080592)
	FAH	-0.201797	-1.26692	-0.129929	0.332888	0.749091	1.14E-05
		(0.046183)*	(0.05236)*	(0.026375)*	(0.062947)*	(0.046537)*	(0.030254)
1992	COV	0.001716	0.323918	-1.09981	-0.439483	0.370969	7.85E-06
		(0.027829)*	(0.002322)*	(0.008368)*	(0.085102)*	(0.074144)*	(0.010106)
	MEAL	N/A	N/A	N/A	N/A	N/A	N/A
	SNK	0.064046*	0.365954*	0.182239*	-0.006114*	-0.509441*	1.68E-05
		(0.014598)	(0.043875)	(0.036088)	(0.092782)	(0.037101)	(0.019256)
		Households with children and a not employed single woman					
		FAFH	FAH	COV	MEAL	SNK	Income
	FAFH	-0.682269	0.490158	0.425904	-0.99443	0.723857	7.97E-05
		(0.081621)*	(0.014842)*	(0.021769)*	(0.057927)*	(0.006123)*	(0.091374)
	FAH	0.352155	-0.763287	-0.595617	0.06833	-0.284636	1.94E-05
		(0.048424)*	(0.043094)*	(0.045741)*	(0.061626)*	(0.055049)*	(0.032393)
1992	COV	0.269464	0.748589	-1.76271	0.298903	0.077982	-4.90E-05
		(0.037319)*	(0.001672)*	(0.037611)*	(0.050893)*	(0.065383)	(0.083937)
	MEAL	-0.116986	0.51667	-1.47153	-0.816984	0.743723	2.27E-05
		(0.088307)	(0.039483)*	(0.047288)*	(0.008057)*	(0.01067)*	(0.027797)
	SNK	0.352786	0.038339	-0.078201	0.308356	-0.83149	1.34E-05
		(0.088444)*	(0.056559)	(0.001908)*	(0.034149)*	(0.05525)*	(0.086492)

*statistically significant at the 5% critical level.

The general results of price and income elasticities for different sub-sample estimations suggest that the intra-household allocation is an important factor for some but not all of the sub-samples. For example, the variation across different types of households with married women is more significant than that among the different types of households with single women. The relatively larger price elasticities and smaller income elasticities for households with single women demonstrate that food purchase decisions for single and married-couple households are different. The results of elasticities and Chow (1960) test statistics on sample estimations are not inconsistent with the hypothesis that in multiple-person households, food purchasing decisions and budget allocations among different types of food categories are made by household members, rather than the unitary decision of the household manager.

Chapter 6 Demand System with Selection Bias

6.1 Estimated Parameters and Elasticities for the System Approach

Demand system estimation with correction for sample selection bias is conducted using the Almost Ideal Demand System (AIDS) model. Linear versions of the AIDS model (LAIDS, equation 3.4.4) are estimated using both seemingly unrelated regression estimation (SURE) and three stage least square (3SLS) estimations with demand constraints imposed.[35] The explanatory variables of the demand system are similar to those of the single equation estimations with the household income variable replaced by total food expenditure, as specified by the AIDS model. Expenditure shares of five food categories are used as the dependent variables of the demand system. Although using multivariate Probit (MP) to model the first stage selection process is an appropriate choice for demand system estimation (Chiang and Lee 1992), the MP estimates could not be obtained, due to the presumed internal structure of the data.[36] Hence, the univariate Probit model was still selected as the first-stage estimation tool. Because the estimates of single equation applications demonstrate that models with different price adjustment processes do not have much variation in the final stage of estimation, the system estimation is based only on method 1 of the price adjustment (where the selection process and seasonal and regional dummies are included). The estimates from 3SLS and linear SURE are provided in Table 6.1.1 to Table 6.1.2 and Appendix 5. The SURE estimates are significant in two-thirds of the coefficients, indicating a good fit of the model with the data. However, a three stage least square (3SLS) constrained demand system is imperative for a consistent estimation of demand relationships because endogenous effect of some independent variables (e.g., total food expenditure) should be considered. Hence, discussion will be focused on this.

The results from the demand system estimations suggest better performance of this approach than for the single equation models. Most of the estimated coefficients are

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35 The non-linear version of the AIDS model with curvature restrictions imposed was investigated without achieving estimation results because of the complicated specification of the model and its conflict with the data.

36 The estimated correlation is outside the range $-1 < r < 1$, which made the variance matrix of estimates singular.

statistically significant for FAFH, FAH, COV and SNK for both 1986 and 1992 data. The prepared meal equation provides less satisfactory estimates than other categories but more than half of the coefficients for this equation are significant. The results from the system estimation suggest that consumption of the food categories is correlated, both theoretically and empirically. Some mostly insignificant estimates of single equation models (such as educational levels, etc.) become significant. The insignificant estimates for system estimations are mainly found in quarterly dummies, implying that seasonal variables are not important factors affecting food demand. The coefficients on prices and total food expenditures are statistically significant as we expected. The inverse Mills ratios are also quite significant in both years. Along with the single equation results, we conclude that considering a selection process in the first step is important.

Table 6.1.1 Estimated Coefficients of Demand System with Restrictions, 1986

	FAFH	*t-ratio*	*FAH*	*t-ratio*	*COV*	*t-ratio*	*Meal*	*t-ratio*	*Snack*	*t-ratio*
Constant	0.4520	16.866*	0.3240	13.558*	0.2110	16.297*	0.0050	1.502	0.0512	3.824*
FULLEMPL	-0.0090	-1.4230	0.0034	0.6050	0.0013	0.4180	0.0006	1.276	0.0103	3.355*
NOEMPL	-0.0690	-8.81*	0.0240	3.489*	0.0087	2.34*	-0.0006	-0.9720	0.0096	2.489*
URBAN	0.0211	3.548*	-0.0145	-2.772*	-0.0085	-3.024*	0.0009	1.91*	0.0008	0.2610
SEX	-0.1070	-11.583*	0.0587	7.204*	0.0039	0.8810	-0.0010	-1.2840	0.0216	4.76*
MARRIED	-0.1220	-3.047*	0.0429	1.2180	0.0251	1.317*	0.0020	0.6140	0.0374	1.907*
WW	-0.0658	-7.294*	0.0264	3.337*	0.0105	2.453*	-0.0007	-1.0190	0.0070	1.5930
AGE	-0.0028	-17.999*	0.0020	14.436*	0.0001	1.0120	0.0000	1.872**	0.0007	9.215*
CHILDREN	-0.0303	-4.61*	0.0120	2.074*	0.0130	4.183*	-0.0001	-0.2150	0.0080	2.499*
NFEARNER	0.0493	12.697*	-0.0303	-8.87*	-0.0122	-6.605*	0.0000	-0.0580	-0.0078	-4.104*
HSIZE	-0.0251	-9.734*	0.0119	5.252*	0.0117	9.588*	-0.0001	-0.2460	0.0044	3.479*
ARRIVAL	-0.0030	-2.223*	0.0027	2.264*	-0.0001	-0.1710	-0.0003	-2.588*	0.0005	0.8030
Q1	0.0007	0.1390	0.0040	0.9250	0.0059	2.506*	0.0016	3.906*	-0.0014	-0.5880
Q2	0.0086	1.716**	-0.0100	-2.282*	-0.0023	-0.9880	0.0002	0.4280	0.0042	1.709**
Q3	0.0179	3.552*	-0.0289	-6.525*	-0.0080	-3.325*	-0.0002	-0.5600	0.0000	-0.0200
GC1	-0.0393	-6.084*	0.0125	2.199*	0.0084	2.748*	0.0027	5.249*	0.0116	3.68*
GC2	-0.0226	-3.476*	0.0103	1.796*	-0.0065	-2.118*	-0.0013	-2.519*	0.0158	4.984*
GC3	0.0129	2.031*	-0.0393	-7.077*	0.0021	0.7070	0.0020	3.311*	0.0111	3.595*
GC4	0.0117	1.685**	-0.0338	-5.534*	0.0076	2.304*	0.0001	0.1070	0.0038	1.111
GC5	0.0234	3.127*	-0.0387	-5.909*	0.0008	0.2220	-0.0002	-0.257*	0.0099	2.724*
EDU2	0.0225	4.198*	-0.0233	-4.941*	-0.0078	-3.064*	0.0008	1.916**	-0.0008	-0.3020
EDU3	0.0488	6.853*	-0.0455	-7.274*	-0.0205	-6.0650	0.0004	0.7740	0.0007	0.2120
EDU4	0.0467	6.525*	-0.0429	-6.834*	-0.0207	-6.116*	0.0003	0.5540	0.0046	1.3210
EDU5	0.0763	10.826*	-0.0618	-9.992**	-0.0340	-10.169*	0.0001	0.133	0.0046	1.3260
HC1	0.0457	3.421*	-0.0646	-5.502*	-0.0022	-0.3510	0.0024	1.995*	0.0092	1.4090
HC2	0.0569	1.4730	-0.0094	-0.2760	-0.0135	-0.7360	-0.0020	-0.6510	-0.0095	-0.5020
HC3	0.0112	0.2940	0.0129	0.3870	-0.0002	-0.0120	-0.0016	-0.5430	-0.0013	-0.0680
HC4	0.0416	1.0640	0.0191	0.5550	-0.0116	-0.6240	-0.0012	-0.3920	-0.0190	-0.9920
HC6	-0.0462	-3.355*	0.0102	0.8400	0.0257	3.929*	0.0017	1.4720	0.0133	1.972*
HC7	-0.0437	-2.756*	0.0167	1.2000	0.0207	2.761*	0.0011	0.8340	0.0139	1.79**
PFAFH	0.0706	13.748*	-0.0291	-6.475*	-0.0123	-5.077*	-0.0008	-1.767	-0.0194	-7.744*
PFAH	0.0451	3.597*	-0.0303	-2.754*	-0.0329	-5.542*	0.0015	1.4580	-0.0046	-0.7500
PCOV	-0.0015	-0.1640	-0.0280	-3.563*	0.0124	2.925*	0.0002	0.2240	0.0052	1.1940
PMEAL	0.0261	2.268*	-0.0086	-0.8540	-0.0147	-2.702*	0.0086	2.496*	0.0026	0.4660
LNTFE	0.0330	16.122*	-0.0120	-5.9320	-0.0187	-16.9040	-0.0005	-0.9330	-0.0045	-3.832*
LAMDA	0.0649	30.728*	0.1600	39.658*	0.0772	37.248*	0.0147	2.963*	0.0629	28.195*

*statistically significant at the 5% critical level **statistically significant at the 10% critical level.

Note: LNTFE is the log total food expenditure. Definitions of other explanatory variables are the same as in single equation applications.

Model Significance:
FAFH: Adjusted R-squared = .36897| F[36, 10088] = 165.43
FAH: Adjusted R-squared = .31037 F[36, 10088] = 127.57
COV: Adjusted R-squared = .24104 F[36, 10088] = 90.31
MEAL Adjusted R-squared = .32678 F[36, 10088] = 110.34
SNK: Adjusted R-squared = .16808 F[36, 10088] = 57.82

Table 6.1.2 Estimated Coefficients of Demand System with Restrictions, 1992

	fafh	*t-ratio*	*fah*	*t-ratio*	*cov*	*t-ratio*	*meal*	*t-ratio*	*snk*	*t-ratio*
Constant	0.5057	34.248*	0.2119	18.099*	0.1705	24.344*	0.0365	6.173*	0.1080	12.925*
WEUROPE	-0.0004	-0.0310	0.0042	0.4440	0.0053	0.969	0.0006	0.6820	-0.0001	-0.0140
SEUROPE	-0.0511	-3.737*	0.0369	3.2540	0.0067	1.037	-0.0021	-1.816*	0.0131	1.7070**
ASIA	0.0190	1.0090	0.0321	2.061*	-0.0288	-3.2410*	-0.0029	-1.838**	-0.0194	-1.842*
OTHERN	-0.0424	-2.269*	0.0551	3.561*	-0.0147	-1.6620**	-0.0016	-1.0100	0.0034	0.3250
FULLEMPL	-0.0146	-2.179*	-0.0003	-0.0560	0.0010	0.317	-0.0014	-2.587*	0.0073	1.941**
NOEMPL	-0.0511	-8.836*	0.0222	4.638*	0.0109	3.9970*	-0.0002	-0.3250	0.0105	3.258*
URBAN	0.0136	2.444*	-0.0079	-1.726**	-0.0093	-3.5490*	0.0011	2.388*	-0.0087	-2.809*
SEX	-0.0340	-7.662*	0.0164	4.504*	-0.0033	-1.552	-0.0009	-2.436*	0.0149	5.979*
MARRIED	-0.0269	-5.065*	0.0331	7.5100	-0.0001	-0.054	-0.0022	-4.843*	0.0035	1.1850
WW	-0.0327	-4.619*	0.0103	1.763*	-0.0021	-0.632	-0.0010	-1.727**	0.0176	4.448*
AGE	-0.0027	-17.049*	0.0015	11.608*	-0.0001	-1.5	0.0000	1.693**	0.0009	10.195*
CHILDREN	-0.0583	-10.078*	0.0125	2.609*	0.0208	7.5830*	0.0020	4.147*	0.0235	7.245*
NFEARNER	0.0565	11.815*	-0.0227	-5.725*	-0.0105	-4.6260*	0.0011	2.682**	-0.0176	-6.575*
HSIZE	-0.0197	-7.862*	0.0082	3.963*	0.0066	5.6060*	-0.0003	-1.2660	0.0042	3.017*
ARRIVAL	-0.0068	-3.105*	0.0046	2.556*	-0.0011	-1.09	0.0001	0.3330	0.0024	1.922*
Q1	-0.0043	-0.8430	0.0089	2.113*	0.0019	0.792	-0.0001	-0.3370	-0.0061	-2.139*
Q2	0.0037	0.7370	0.0006	0.1550	-0.0041	-1.6970**	-0.0008	-1.996*	0.0020	0.6930
Q3	0.0186	3.68*	-0.0171	-4.092*	-0.0058	-2.4220*	-0.0010	-2.302*	-0.0098	-3.468*
GC1	-0.0679	-11.431*	0.0516	10.469*	0.0015	0.515	0.0019	3.803*	0.0142	4.2610*
GC2	-0.0479	-7.695*	0.0586	11.25*	-0.0159	-5.3220*	0.0004	0.6910	0.0263	7.447*
GC3	0.0126	-2.113*	0.0095	1.918*	-0.0073	-2.5820*	0.0012	2.53*	0.0068	2.0440
GC5	0.0063	0.8170	0.0044	0.6890	-0.0060	-1.6340	0.0000	0.0680	0.0097	2.255*
GC6	-0.0140	-1.914*	0.0327	5.409*	-0.0077	-2.2350*	-0.0001	-0.0930	0.0008	0.1960
EDU2	0.0298	5.154*	-0.0108	-2.259*	-0.0147	-5.3820*	0.0011	2.377*	-0.0009	-0.2760
EDU3	0.0693	9.441*	-0.0334	-5.508*	-0.0282	-8.1130*	0.0007	1.1680	-0.0056	-1.3590
EDU4	0.0676	9.818*	-0.0379	-6.647*	-0.0259	-7.9530*	0.0014	2.466*	-0.0013	-0.3310
EDU5	0.0835	11.16*	-0.0432	-6.968*	-0.0357	-10.0860*	-0.0004	-0.6290	-0.0037	-0.8850
PFAFH	0.0986	22.185*	-0.0490	-13.493*	-0.0223	-10.3310*	-0.0015	-3.7200*	-0.0409	-16.356*
PFAH	0.0354	7.902*	-0.0144	-3.147*	-0.0263	-8.5070*	-0.0005	-0.6030	-0.0054	-1.648**
PCOV	0.0209	14.29*	-0.0395	-10.585*	0.0069	2.1780*	0.0005	0.8280	-0.0091	-3.674*
PMEAL	0.0236	6.874*	-0.0235	-6.305*	-0.0105	-4.1010*	-0.0025	-3.6250*	-0.0070	-2.007*
PSNK	0.0581	15.479*	-0.0240	-5.349*	-0.0104	-23.5670*	-0.0015	-2.093*	-0.0130	-29.31*
LNTFE	-0.0067	-10.872*	0.0016	3.292*	0.0016	5.3270*	-0.0015	-7.998*	0.0044	12.62*
LAMDA	0.0745	38.119*	0.1232	39.268*	0.0567	32.5880*	0.0206	92.0010*	0.0711	33.97*

*statistically significant at the 5% critical level **statistically significant at the 10% critical level.

Note: LNTFE is the log total food expenditure. Definitions of other explanatory variables are the same as in single equation applications.

Model Significance:
FAFH: Adjusted R-squared = .34270 F[35, 10619] = 159.71
FAH: Adjusted R-squared = .25418 F[35, 10619] = 104.74
COV: Adjusted R-squared = .19843 F[35, 10619] = 76.36
Meal: Adjusted R-squared = .43846 F[35, 10619] = 220.58
Snk: Adjusted R-squared = .20597 F[35, 10619] = 79.96

For 1986, households with full-time working managers demonstrate a statistically significant and positive effect on snack expenditure. Negative and significant effects on FAFH are observed in the 1992 data. The prepared meal estimate for this coefficient is significant and negative for 1992. The overall effects of full-time working household heads indicate that full-time work is not necessarily associated with higher consumption of FAFH and prepared meals, which conforms to the results of single equation estimation.

Households with unemployed heads have a negative effect on FAFH expenditure, while expenditure on other types of food is positively influenced by this group of households. Households in urban areas consume relatively more FAFH and prepared meals and less FAH and COV than those in rural areas, likely resulting from the fact that the availability of FAFH and prepared meals in rural areas is lower. This *urban* variable has a significant estimate that is different from the single equation result but consistent with Reynolds and Goddard's (1993) study using FFES 86 data.

The gender of the household head is a statistically significant variable with a negative coefficient in FAFH consumption, which is consistent with the results of the single equation applications. Households headed by female managers will spend less on FAFH than those headed by male managers. On the other hand, female-headed households spend more on FAH and snacks than others. The negative and statistically significant estimates of the coefficients on married couple households indicate that FAFH expenditure is relatively lower for households of married people, while the positive estimates for FAH and snacks suggest a strong "at home preference".

The age of the household head has a positive relationship with FAH, Meal and Snack consumption, but FAFH expenditure decreases with increases in age for household heads. The presence of children variables are significant with positive coefficients for all food categories except for FAFH, implying that the more children there are in a household, the less the expenditure on eating out. The number of full time earners variable provides results similar to those of the single equation application: The more full-time earners in a given household, the more money is spent on FAFH, and the less money is spent on other types of foods. Total household size demonstrates an almost opposite effect to the number of full-time earners: Large households spend less on FAFH and prepared meals; small households spend less on FAH, COV and snacks.

The immigrant arrival year coefficients indicate that households of new immigrants consume more FAH and snacks but less FAFH, COV and prepared meals than do households consisting of Canadian-born or longer-established immigrants. This could imply changes in social behavior or economic conditions for new immigrants after being settled in Canada for several years.

Compared to the fourth quarter dummy variable, the seasonal dummy variables are significant with a positive effect in the third quarter (July-September) for FAFH consumption, indicating that summer is the season of more eating out expenditures. However, the third quarter estimates indicate negative effects on expenditure of other foods. Results suggest that expenditure for FAH, COV and prepared meals increases in the first quarter, while the second quarter (April-June) has negative effects on FAH and COV but positive effects on snack expenditure. The changes in household preference with respect to different seasons/quarters suggest a substitution between choices of food categories. The estimates of regional dummies exhibit statistically significant and similar results to single equation applications. Compared to the reference provinces (British Columbia for 1986, Manitoba and Saskatchewan for 1992), households in the province of Ontario (GC3) and Alberta (GC5) have positive effects on FAFH consumption, indicating that people in these provinces spend more on FAFH than people in other provinces. Households in the Atlantic provinces (GC1) have a positive effect on all food categories except FAFH. The province of Quebec dummy (GC2) has a positive effect on FAH and snacks, and a negative effect on other food categories. Ontario demonstrates positive effects on all food categories except for FAH.

Based on the reference group EDU1 (households with managers having less than 9 years education), all educational level coefficients are positive and mostly significant for FAFH and prepared meals. Results indicate that higher educated people spend more on FAFH (Edu5>Edu4>Edu3), but less on other food categories, especially for FAH. Coefficients of education dummies are mostly negative for convenience food but positive for snacks. Because convenience foods include canned food etc. and snacks include fruit, yogurt etc., this result may imply that higher educated people are more concerned about healthy food. Households with people with college diplomas spend more on prepared meals than others (1992 result, statistically significant). Based on the reference group HC5 (single parent households), the estimates for the household composition indexes for 1986 indicate that single person households (HC1) tend to spend more on FAFH than other types of households. Households with relatives (HC6, HC7) have a positive effect on COV and Snacks, but negative effects on FAFH.

Table 6.1.3 Estimated Elasticities from Demand System Application, 1986

	Elasticities with respect to Socioeconomic Variables				
	FAFH	*FAH*	*COV*	*MEAL*	*SNK*
Age	-0.540426	0.163487	-0.332672	4.89094	0.0632
	(0.003603)*	(0.004721)*	(0.001552)*	(0.008155)*	(0.003033)*
Number of full time earner	0.0912081	-0.0339386	-0.0150464	-0.40729	-0.0085344
	(0.003154)*	(0.002876)*	(0.006341)*	(0.001324)*	(0.006983)
Household size	-0.26567	0.000426	0.232474	0.706404	0.041311
	(0.004089)*	(0.003128)	(0.006249)*	(0.009366)*	(0.009602)*
Immigrant arrival year	-0.000485	0.004181	0.00733	0.152907	0.009922
	(0.00027)*	(0.00139)*	(0.003706)*	(0.004779)*	(0.007865)
Total food expenditure	1.22086	1.174166	0.838913	1.53176	1.098652
	(0.007695)*	(0.005)*	(0.00495)*	(0.007072)*	(0.006553)*
	Price Elasticities				
	FAFH	*FAH*	*COV*	*MEAL*	*SNK*
FAFH	-0.606364	-0.016446	-0.002605	-4.77202	-0.057927
	(0.033518)*	(0.065456)	(0.078153)	(0.079499)*	(0.025838)*
FAH	-0.006748	-0.966611	-0.34071	-3.87139	-0.066424
	(0.060188)	(0.034501)*	(0.051605)*	(0.085106)*	(0.005403)*
COV	-0.102942	0.000115	-0.708823	-1.19936	0.044384
	(0.049932)*	(0.027271)	(0.085633)*	(0.025208)*	(0.038204)
MEAL	0.094967	0.065795	0.061687	-1.080723	0.11528
	(0.019796)*	(0.000884)*	(0.004303)*	(0.085273)*	(0.081144)*
SNK	0.011255	-0.117985	-0.028077	5.33669	-0.770216
	(0.001596)*	(0.098298)	(0.005234)*	(0.024089)*	(0.0039)*

*statistically significant at the 5% critical level.

Table 6.1.3 and Table 6.1.4 provide the elasticities for demand with respect to price and continuous socioeconomic variables from demand system estimation. The elasticities with respect to price indicate that FAFH is the most own-price inelastic category while prepared meals are the most own-price elastic category of the five food groupings. Prepared meals are quite elastic (<-1), suggesting that this category is relatively more sensitive to its own price changes. The cross price elasticities are mostly positive with a few exceptions, indicating that most food categories in this study are mutually substitutable. The elasticities of demand with respect to total food expenditure (TFE) are positive for all food categories, and most of them are close to or greater than one.

Table 6.1.4 Estimated Elasticities from Demand System Application, 1992

Elasticities with respect to Socioeconomic Variables					
	FAFH	*FAH*	*COV*	*Meal*	*SNK*
Age	-4.79E-01	8.19E-02	-3.54E-01	5.72E-02	4.49E-02
	(0.003801)*	(0.007753)	(0.002906)*	(0.000266)*	(0.001194)*
Number of full time earner	0.134973	-0.037388	-0.107072	-0.031251	-0.069859
	(0.001791)*	(0.00242)*	(0.001968)*	(0.005002)*	(0.002641)*
Household size	-0.215766	0.07166	0.009114	0.233724	0.086097
	(0.007796)*	(0.002247)*	(0.001449)*	(0.001476)*	(0.007848)*
Immigrant arrival year	-0.04086	0.032486	0.012363	1.56E-03	2.70E-02
	(0.004332)*	(0.009342)*	(0.005311)*	(0.005187)	(0.002055)*
Total food expenditure	1.12021	0.879779	0.799946	1.47189	0.97045
	(0.005854)*	(0.000498)*	(0.003545)*	(0.002542)*	(0.009661)*
Price Elasticities					
	FAFH	*FAH*	*COV*	*Meal*	*SNK*
FAFH	-0.684605	0.079959	0.085338	0.269622	0.140623
	(0.080444)*	(0.055805)	(0.071269)	(0.098956)*	(0.044718)*
FAH	0.448874	-0.962335	0.054387	0.172673	0.625862
	(0.064242)*	(0.010054)*	(0.08612)	(0.059257)*	(0.051221)*
COV	3.62093	0.056	-0.916027	-0.591493	0.002032
	(0.080657)*	(0.039462)	(0.067307)*	(0.023444)*	(0.049425)
MEAL	0.032331	0.018096	0.006343	-1.278254	-0.048213
	(0.09592)	(0.029638)	(0.090389)*	(0.099325)*	(0.050196)*
SNK	0.080677	0.04811	0.033804	0.238878	-1.10714
	(0.005837)*	(0.060736)	(0.035591)	(0.006202)*	(0.01293)*

*statistically significant at the 5% critical level.

The elasticities with respect to age variables are positive for FAH and Meal and negative for other food categories, implying that an increase in the age of the household head will cause an expansion in purchases of FAH and Meal, and a contraction of other types of food consumption. The number of full-time earners has a positive elasticity with respect to FAFH expenditure but is negative with respect to other food categories, indicating that with more income sources in a family, it is more likely for them to eat out. Elasticities with respect to total household size are positive in all food categories expect FAFH, which conforms to the results from the single equation estimation and implies that the more people in one family, the less expenditure on FAFH. Immigrant arrival year has a negative impact on FAFH and a positive one on the other categories, again suggesting that the later the immigrant comes to Canada, the less emphasis is placed on eating meals away from home.

6.2 Comparison with Elasticities from Single Equation Demand Estimation

The elasticities obtained from demand system and single equation estimation are different in magnitude and in sign for some variables. For example, elasticities of FAFH with respect to household size are positive (0.01-0.08) from single equation estimations and negative from demand system (-0.22-0.27). Expenditure elasticities of prepared meals are large and positive from system estimations (1.47-1.53), while income elasticities of prepared meals from single equations are small and even negative (-0.06-0.12). Since demand system estimation is more consistent with the theory (demand restrictions can be imposed and simultaneous cross equation effects are captured), and is statistically more significant in overall results, we consider it a better approach than single equation estimation for simulation and marketing implication uses.

Table 6.2.1 Comparison of Own-price Elasticities

Elasticities	FAFH	FAH	COV	MEAL	Snack
Single Equation	-0.36– -0.54	-0.38– -0.84	-0.72 – -0.79	-0.998– -1.13	-0.04 – -0.66
Demand System	-0.60 – -0.68	-0.96	-0.71 – -0.91	-1.08 – -1.27	-0.77 – -1.10

The comparison of own-price elasticities from single equation and demand system estimations is presented in Table 6.2.1. In general, own price elasticities obtained from the demand system are slightly larger in scale than those from single equation models. The elasticity with respect to the age variable has similar signs and scales for most food categories except convenience food (negative in demand system result). Elasticities with respect to the number-of-full-time-earners have the same signs and analogous scales in both single equation and system estimation. Elasticities with respect to the immigrant arrival year have similar signs for FAFH, FAH and snacks, but different signs for COV and prepared meals. As we employed total food expenditure instead of household income as the income measurement variable in demand system estimation, the elasticities with respect to the total food expenditure for all food categories (0.8389–1.5318) are much larger than income elasticities from single equation models (0.07–0.54). According to Edgerton (1997), the income elasticity of food category *i* can be specified as a product of the income elasticity for total food, and the total food expenditure elasticity for category *i*. i.e.,

$$\eta_i = \eta_G \times \eta_{exp} \qquad i \subset G \tag{6.2.1}$$

where η_i is the income elasticities for food category *i*, G is total food group, η_G is the income elasticity for food, and η_{exp} is the total food expenditure elasticity for food category *i*. Because food is a necessity and the income elasticity for total food group (η_{exp}) is generally smaller than 1, (mostly smaller than 0.5), the income elasticity for each food category (η_i, in this study is η_{FAFH}, η_{FAH}, η_{COV}, η_{MEAL} and η_{Snack}) will be smaller than the respective total food expenditure elasticity (η_{exp}). The results verified Edgerton's (1997) theory regarding the existence of discrepancies between income and expenditure elasticities.

6.3 Sub-sample Estimation Results

In order to verify the intra-household allocation effects obtained from single-equation application, the sub-sample estimations with respect to adult female household members were also conducted using the demand system approach. The classifications of different households with respect to female household members are same as those used in the single equation method. Detailed category and household numbers are presented in Table 5.4.1.

Table 6.3.1 Elasticities for Household with Married Woman with Children

	1986					1992				
	FAFH	FAH	COV	MEAL	SNK	FAFH	FAH	COV	MEAL	SNK
Household with children and not-employed married woman										
FAFH	-0.336958	0.0749969	0.131866	0.173701	0.144157	-0.199565	0.326584	0.471408	0.6054	0.4464
	(0.0504661)*	(0.0140931)*	(0.0253353)*	(0.0344364)*	(0.0288735)*	(0.0353061)*	(0.0182325)*	(0.0273284)*	(0.0357)*	(0.0259)*
FAH	0.095186	-0.858744	0.105148	0.130506	0.112424	0.0393568	-0.94841	0.0423336	0.0513	0.0403
	(0.0052262)*	(0.0296216)*	(0.0121012)*	(0.0127938)*	(0.012029)*	(0.00131)*	(0.0043899)*	(0.0022506)*	(0.0023)*	(0.00226)*
COV	-1.19141	-0.772789	-0.9777	-1.50104	-1.22739	0.0249314	0.0194786	-0.935819	0.0323	0.0252
	(0.204716)*	(0.199081)*	(0.32663)*	(0.316124)*	(0.242378)*	(0.0006156)*	(0.0006481)*	(0.0054848)*	(0.0009)*	(0.00075)*
MEAL	-0.0271013	-0.0290067	-0.013892*	-0.013892*	-0.0449098	-0.0114756	-0.0386919	0.0724107	0.07241	-0.0176
	(0.009966)*	(0.0104617)*	(0.0367096)*	(0.0367096)*	(0.016602*	(0.0014442)*	(0.0031448)*	(0.016568)*	(0.0165)*	(0.0016)*
SNK	-0.714366	-0.440229	-0.626311	-0.0449098	-0.62393	0.107956	0.080067	0.111802	-0.01764	-0.8522
	(0.0979959)*	(0.0919855)*	(0.0964466)*	(0.016602)*	(0.140432*	(0.0032793)*	(0.0030465)*	(0.0037041)*	(0.00166)*	(0.0064)*
Household with children and part-time employed married woman										
FAFH	-0.329364*	0.206517*	0.354349*	0.455329*	0.379009*	-0.254682*	0.376043*	0.531372*	0.6805*	0.5115*
	(0.0499345)	(0.0220482)	(0.0377017)	(0.049594)	(0.042271)	(0.0368643)	(0.0193119)	(0.0279019)	(0.0367)	(0.0263)
FAH	-0.169423*	-1.12155*	-0.185645*	-0.22764*	-0.196581*	0.0092127*	-0.971376*	0.0109749*	0.0131*	0.01057*
	(0.0042132)	(0.0140889)	(0.0098435)	(0.0104457	(0.0099992)	(0.00012)	(0.0036805)	(0.0002785)	(0.0003)	(0.0003)
COV	-0.134679*	-0.0971108*	-1.11778*	-0.178175*	-0.153031*	-0.0899966*	-0.084997*	-1.08571*	-0.1297*	-0.1041*
	(0.0110426)	(0.0080728)	(0.0208372)	(0.0158411)	(0.0144046)	(0.002078)	(0.0038098)	(0.0067717)	(0.0045)	(0.0039)
MEAL	0.0216468*	-0.0119273*	0.0868532*	0.0868532*	-0.0145952*	-0.0198298*	-0.0495337*	0.073661*	0.0736*	-0.0275*
	(0.0028592)	(0.0018265)	(0.0248836)	(0.0248836)	(0.0023417)	(0.001624)	(0.0033047)	(0.0148674)	(0.0148)	(0.0019)
SNK	0.406402*	0.275163*	0.405093*	-0.0145952*	-0.480688*	0.236888*	0.210932*	0.27485*	-0.0275*	-0.6940*
	(0.0211033)	(0.0192502)	(0.0222555)	(0.0023417)	(0.0274584)	(0.0049737)	(0.0079004)	(0.0085404)	(0.0019)	(0.0103)
Household with children and full-time employed married woman										
FAFH	-0.430626	0.253036	0.396892	0.487322	0.401418	-0.292015	0.405554	0.574131	0.7014	0.5290
	(0.0307064)*	(0.0142173)*	(0.024207)*	(0.0303917)*	(0.0241953)*	(0.0395096)*	(0.0202712)*	(0.0323054)*	(0.03953)*	(0.0273)*
FAH	-0.104618	-1.08692	-0.129122	-0.152961	-0.130201	-0.012061	-0.989639	-0.016555	-0.0190	-0.0154
	(0.0016939)*	(0.0069724)*	(0.0046723)*	(5.22E-03)*	(0.0049939)*	(0.0001815)*	(0.0045601)*	(0.0006128)*	(0.00063)*	(0.0006)*
COV	0.0283947	0.0240454	-0.936827	0.0406442	0.0341512	0.0468938	0.0481769	-0.899052	0.0722	0.0591
	(0.0007189)*	(0.0012749)*	(0.0060888)*	(1.61E-03)*	(0.0014404)*	(0.0013658)*	(0.0019902)*	(0.0056654)*	(0.0026)*	(0.0023)*
MEAL	0.0413905	0.0045457	0.121537	0.121537	0.0092128	0.0128121	-0.025441	0.11769	0.1177	0.00371
	(0.0041348)*	(0.0010973)*	(0.0227932)*	(0.0227932)*	(0.0015649)*	(0.0012519)*	(0.0019382)*	(0.0211969)*	(0.0211)*	(0.0005)*
SNK	0.0816334	0.0641319	0.0925661	0.0092128	-0.863811	0.121383	0.120592	0.158903	0.00371	-0.8137
	(0.0024298)*	(0.0024664)*	(0.0029756)*	(0.0015649)*	(0.0073805)*	(0.003299)*	(0.0052935)*	(0.0060316)*	(0.0005)*	(0.00754)*

*Statistically significant at the 5% critical level.

Table 6.3.1 [37]provides the estimated price elasticities and standard errors for the three sub-samples of households with married women and children, with respect to women's employment status from the system estimations. The calculated elasticities are mostly statistically significant at a 5% critical level. FAFH consumption is relatively more price elastic for households with women working full-time, implying that households with working women have a higher tendency to eat out and are more sensitive to the price changes of FAFH. FAH consumption is relatively more elastic for households with women working part-time, although the price elasticities on FAH with respect to three sub-samples are quite similar. Price elasticities for other food categories are also close across the three sub-samples. The highest price elasticities across all food categories are FAH, suggesting that this is the most sensitive food category for households with a married woman and children. In general, the majority of food expenditures for this type of households is allocated to food-at-home.

Table 6.3.2 provides the estimated price elasticities and standard errors for the households of married women without children from the system estimation. The calculated elasticities are significant at a 5% critical level for most of the categories. The price elasticities with respect to FAFH for households with married, working women without children are higher than those for households with-children groups, indicating that households with working women and no-children are more sensitive to price changes on FAFH. The result is also consistent with the negative effect of children on FAFH consumption obtained earlier. The sub-sample of households with married women stay at home with no child has lower price elasticities on FAFH than other without-children groups, implying that the preferences on FAFH are different for working and non-working women. In the households with married women and no-child, the price elasticities of all type of foods for working women are generally larger in scale than for the households with women who stay-at-home. Associated with the results of Table 6.3.1, the elasticities suggest that households with working, married women are more sensitive to food price changes than households with stay-at-home married women.

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37 The estimated coefficients are not presented but can be retrieved.

Table 6.3.2 Price Elasticities for Households with a Married Woman, No Children

	1986					1992				
	FAFH	FAH	COV	MEAL	SNK	FAFH	FAH	COV	MEAL	SNK
Households with a not-employed married woman, no children										
FAFH	-0.196887 (0.016502)*	0.0723017) (0.0049401*	0.220162 (0.011145)*	0.314395 (0.0150575)*	0.246226 (0.0120026)*	-0.126056 (0.0255553)*	0.254959 (0.0113417)*	0.394013 (0.0191974)*	0.5366 (0.0255)*	0.3738 (0.0173)*
FAH	0.0069241 (0.0001029)*	-0.950241 (0.0045359)*	0.0077653 (0.0004187)*	9.11E-03 (4.31E-04)*	0.0070768 (3.91E-04)*	0.007548 (9.93E-05)*	-0.951562 (0.0038819)*	0.008932 (0.0002087)*	0.0108 (0.0002)*	0.0086 (0.0002)*
COV	0.126146 (0.0037234)*	0.0802385 (0.0029657)*	-0.786184 (0.0067787)*	0.159321 (4.91E-03)*	0.131581 (0.0041486)*	0.0208151 (0.0004206)*	0.0167607 (0.0005242)*	-0.913867 (0.0046011)*	0.0287 (0.0007)*	0.0228 (0.0006)*
MEAL	0.0599532 (0.004314)*	0.0099371 (0.0012523)*	0.213799 (0.0307996)*	0.213799 (0.0307996)*	0.0206057 (0.0018219)*	-0.0122134 (0.0011533)*	-0.0375646 (0.0024329)*	0.11057 (0.0147614)*	0.1105 (0.0147)*	-0.0187 (0.0012)*
SNK	0.319966 (0.0088261)*	0.192265 (0.0072653)*	0.334522 (0.0099953)*	0.0206057 (0.0018219)*	-0.568955 (0.0119961)*	0.216419 (0.0045011)*	0.16799 (0.0060189)*	0.249577 (0.0076933)*	-0.01879 0.00127)*	-0.6966 (0.0089)*
Households with a part-time employed married woman, no children										
FAFH	-0.497587* (0.0161872)	0.112894* (0.0048398)	0.231846* (0.0109105)	0.300017* (0.0140634)	0.247368* (0.0114223)	-0.296829* (0.0386476)	0.346424* (0.0169474)	0.524365* (0.0300802)	0.6507* (0.0381)	0.4995* (0.0285)
FAH	-0.172784* (0.0039462)	-1.14955* (0.0106627)	-0.232582* (0.0092621)	-0.266534* (0.0095159)	-0.231361* (0.0092515)	0.0472254* (0.0008211)	-0.891316* (0.0079959)	0.085273* (0.0063106)	0.0952* (0.0064)	0.0812* (0.0062)
COV	0.0880654* (0.0024138)	0.0768886* (0.0035103)	-0.83663* (0.0064621)	0.130417* (4.48E-03)	0.11098* (0.0038644)	-0.0327684* (0.0008237)	-0.0420974* (0.0023515)	-0.993624* (0.0076193)	-0.0581* (0.0025)	-0.0490* (0.0023)
MEAL	-0.0296994* (0.0024525)	-0.0470386* (0.0035101	0.0747573* (0.0137349)	0.0747573* (0.0137349)	-0.0686044* (0.0051102)	0.0592878* (0.0055799)	0.0219466* (0.0025688)	0.189217* (0.0256141)	0.1892* (0.0256)	0.0569* (0.0053)
SNK	0.233903* (0.0068701)	0.179238* (0.006629)	0.279958* (0.0091237)	-0.0686044* (0.0051102)	-0.655523* (0.0106048)	0.137043* (0.0034402)	0.164056* (0.0081339)	0.209351* (0.0089226)	0.0569* (0.0053)	-0.7419* (0.0104)
Households with a full-time employed married woman, no children										
FAFH	-0.489194 (0.0132506)*	0.209441 (0.0057113)*	0.356984 (0.010109*	0.43178 (0.012889)*	0.356125 (0.0100241)*	-0.309753 (0.0359056)*	0.402016 (0.0180324)*	0.590283 (0.0294858)*	0.7064 (0.0358)*	0.5437 (0.0252)*
FAH	-0.0278197 (0.0001975)*	-1.01015 (0.0025377)*	-0.0417053 (0.0010206)*	-0.0470337 (1.06E-03)*	-0.0410515 (0.0010172)*	-0.0138598 (0.0002186)*	-0.99735 (0.0038579)*	-0.0261249 (0.0010681)*	-0.0285 (0.0010)*	-0.0242 (0.0010)*
COV	0.0611282 (0.0009777)*	0.0593716 (0.0015027)*	-0.872598 (0.0032964)*	0.0964732 (1.97E-03)*	0.0827034 (0.0017713)*	0.0904583 (0.0028874)*	0.120371 (0.0047525)*	-0.794112 (0.0070784)*	0.1676 (0.0057)*	0.1416 (0.0053)*
MEAL	-0.0046089 (0.0003451)*	-0.0352161 (0.0014611)*	0.118338 (0.0102587)*	0.118338 (0.0102587)*	-0.0486465 (0.0020058)*	0.0041691 (0.000693)*	-0.0282959 (0.0020347)*	0.127169 (0.0160257)*	0.1271 (0.0160)*	-0.0051 (0.0005)*
SNK	0.248334 (0.0047972)*	0.223937 (0.0050955)*	0.329048 (0.0068878)*	-0.0486465 (0.0020058)*	-0.624249 (0.0077242)*	0.0961556 (0.0018485)*	0.125741 (0.0043533)*	0.159379 (0.0049175)*	-0.0051 (0.0005)*	-0.8076 (0.0062)*

*statistically significant at the 10% critical level.

Table 6.3.3 Price Elasticities for Households with a Single Woman, No Children

	1986					1992				
	FAFH	FAH	COV	MEAL	SNK	FAFH	FAH	COV	MEAL	SNK
Households with a not employed single woman, no children										
FAFH	-0.258717 (0.0565279)*	0.0648601 (0.0149746)*	0.203817 (0.0308883)*	0.290635 (0.0457958)*	0.231656 (0.0366258)*	0.323982 (0.181679)*	0.499686 (0.0809913)*	0.803845 (0.166107)*	0.9655 (0.1832)*	0.6845 (0.1251)*
FAH	0.0372987 (0.0014491)*	-0.890015 (0.0241373)*	0.0494289 (0.0085092)*	0.056378 (0.0085292)*	0.0467242 (0.0083154)*	-0.239334 (0.0141533)*	-1.14314 (0.0533679)*	-0.316187 (0.0415248)*	-0.3498 (0.0402)*	-0.2854 (0.0372)*
COV	0.475596 (0.0685956)*	0.319913 (0.0417257)*	-0.320295 (0.0846201)*	0.620508 (0.0861599)*	0.501236 (0.0738859)*	-0.0547831 (0.0049689)*	-0.0605066 (0.0154925)*	-0.923117 (0.0384223)*	-0.08335 (0.0159)*	-0.0678 (0.0144)*
MEAL	0.0447664 (0.0158787)*	0.0156516 (0.0062333)*	0.190646 (0.0919872)*	0.190646 (0.0919872)*	0.0229826 (0.0086068)*	0.185104 (0.0461847)*	0.105017 (0.0290839)*	0.425259 (0.221866)*	0.7071* (0.8525)*	0.1945 (0.0505)*
SNK	-0.364589 (0.0508648)*	-0.222651 (0.03058)*	-0.387544 (0.0534646)*	0.0229826 (0.0086068)*	-1.27694 (0.0736518)*	0.0888223 (0.0052905)*	0.0750402 (0.0077816)*	0.107718 (0.0091972)*	0.1945 (0.0505)*	-0.7550 (0.0282)*
Households with a part-time employed single woman, no children										
FAFH	-0.547653* (0.0583038)	0.191075* (0.0184967)	0.305232* (0.0501266)	0.358043* (0.0545237)	0.290464* (0.039475)	-0.434368* (0.0672373)	0.332154* (0.0457489)	0.451565* (0.0577855)	0.5329* (0.0668)	0.4176* (0.0532)
FAH	-0.0367895* (0.0014903)	-1.0125* (0.015604)	-0.0622969* (0.0053299)	-0.0698149* (0.0059567)	-0.0613873* (0.005825)	-0.0258965* (0.001477)	-0.993182* (0.0226795)	-0.0627739* (0.0107243)	-0.0671* (0.0108)	-0.0577* (0.0102)
COV	0.175946* (0.0143157)	0.198277* (0.021504)	-0.630395* (0.0297356)	0.296141* (0.0268802)	0.245932* (0.0214522)	-0.0386478* (0.0029621)	-0.0672793* (0.0098021)	-0.93216* (0.0311444)	-0.0841* (0.0100)	-0.0720* (0.0091)
MEAL	-0.0693764* (0.0166396)	-0.0882687* (0.0194201)	-0.010203 (0.0169684)	-0.010203 (0.0169684)	-0.115775* (0.0256739)	0.0393822* (0.0096168)	0.0098665* (0.0040447)	0.134021* (0.0479736)	0.1401* (0.0737)	0.0374* (0.0094)
SNK	0.136269* (0.0086606)	0.15763* (0.0174253)	0.216979* (0.0203937)	-0.115775* (0.0256739)	-0.708539* (0.0253541)	0.0195834* (0.0014444)	0.0289927* (0.0036216)	0.0358765* (0.0040486)	0.0374* (0.0094)	-0.8580* (0.0229)
Households with a single woman no child working full-time										
FAFH	-0.76425 (0.0211804)*	0.0933046 (0.0061783)*	0.148145 (0.014357)*	0.171657 (0.0162121)*	0.139567 (0.0124581)*	-0.494121 (0.0621175)*	0.320938 (0.0324607)*	0.440754 (0.0509002)*	0.5232 (0.0605)*	0.3950 (0.0415)*
FAH	0.108886 (0.0030352)*	-0.764345 (0.0178994)*	0.228823 (0.0158836)*	0.247656 (0.0161942)*	0.220086 (0.0157052)*	-0.0990408 (0.0048995)*	-1.14228 (0.0286993)*	-0.213354 (0.0245218)*	-0.2309 (0.0248)*	-0.1963 (0.0237)*
COV	0.0600531 (0.0033459)*	0.0875847 (0.0080077)*	-0.789159 (0.0166268)*	0.122703 (0.0097228)*	0.105685 (0.0086797)*	0.116959 (0.0057846)*	0.18105 (0.0149658)*	-0.690926 (0.0139163)*	0.2383 (0.01679)*	0.2005 (0.0151)*
MEAL	-0.0608784 (0.0106397)*	-0.0990061 (0.0170867)*	0.026633 (0.0230292)	0.026633 (0.0230292)	-0.122028 (0.0202205)*	0.0520955 (0.0094322)*	0.0218232 (0.0047664)*	0.326981 (0.0551255)*	0.2234 (0.0551)*	0.0535 (0.0097)*
SNK	0.139407 (0.0057734)*	0.194531 (0.0143074)*	0.2514 (0.0159735)*	-0.122028 (0.0202205)*	-0.681409 (0.0189688)*	0.174382 (0.0099256)*	0.259846 (0.0202302)*	0.321628 (0.0227578)*	0.0535 (0.0097)*	-0.6123 (0.0251)*

*statistically insignificant at the 5% critical level.

Table 6.3.3 provides the estimated price elasticities and standard errors for sub-samples of households with a single woman without children from the system estimation. The calculated elasticities are mostly significant at the 5% critical level. Price elasticities of FAFH for single women households are larger than those for married women households (Table 6.3.1 and Table 6.3.2), indicating that single women households are more sensitive to FAFH prices than married women households. The price elasticities for other types of foods are generally lower for single women households than for married women households. Along with the FAFH elasticities, these results imply that single women households have a greater tendency for expenditure on FAFH and less on food-at-home than married women households. The price elasticity of FAFH for households with a single no-children woman increases when the employment status of women changes from "stay-at-home" to part-time and full time work, once more suggesting that working women are more sensitive to FAFH price variations. For other types of foods, households with a single woman who stays at home or works part time generally have higher elasticities than households with full-time working single women.

Table 6.3.4 provides the estimated price elasticities and standard errors for sub-samples of households with a single woman and children (1992) from system estimation[38]. The calculated elasticities are mostly significant at a 5% critical level. Compared with Table 6.3.3, this category has relatively larger elasticities for FAH and COV, but smaller elasticities for FAFH, implying that households with single woman and children groups spend less on FAFH.

The general price elasticities for different sub-samples demonstrate that preferences and behavior are vary across households with different types of female and other household members. Variations in marital and employment status, and the presence of children in the households have effects on preferences and choices of household members, and affect household expenditure on food. The food category with the most diverse elasticities across different sub-samples is the FAFH, indicating that this category

38 Estimation of the 1986 sub-sample cannot be achieved due to the limited degree of freedom.

is strongly affected by household members' employment status and the presence of children.

Table 6.3.4 Price Elasticities for Households with a Single Woman and Children

	FAFH	FAH	COV	MEAL	SNK
Households with children and a not-employed single woman, 1992					
FAFH	-0.501337 (0.0551772)*	0.071462 (0.0160046)*	0.0959726 (0.0198697)*	0.17997 (0.0385154)*	0.11593 (0.024465)*
FAH	-0.273127 (0.0194895)*	-1.1943 (0.0423813)*	-0.284971 (0.0249827)*	-0.353762 (0.0317993)*	-0.278058 (0.0249591)*
COV	-0.465219 (0.0399091)*	-0.367393 (0.0466968)*	-1.4469 (0.0763396)*	-0.596727 (0.0649174)*	-0.467599 (0.0499734)*
MEAL	-0.0994373 (0.0294253)*	-0.0952026 (0.0265334)*	-0.108155 (0.033817)*	-0.108155 (0.033817)*	-0.0988844 (0.0281207)*
SNK	0.518474 (0.0513241)*	0.374532 (0.042601)*	0.509861 (0.0543431)*	-0.0988844 (0.0281207)*	-0.3915 (0.0652084)*
Households with children and a part-time employed single woman, 1992					
FAFH	0.168656 (0.207228)	0.557098 (0.117674)*	0.769962 (0.149348)*	0.994231 (0.213919)*	0.761189 (0.180922)*
FAH	0.83123 (0.0611823)*	-0.094431 (0.219116)	1.02536 (0.208949)*	1.21831 (0.222407)*	0.960307 (0.213151)*
COV	0.169625 (0.0167385)*	0.128764 (0.0172192)*	-0.729127 (0.037469)*	0.215412 (0.0224633)*	0.164353 (0.0190205)*
MEAL	0.0346065 (0.0110722)*	-0.0124207 (0.0046363)*	0.160509 (0.0983189)*	0.160509 (0.0983189)*	0.0242004 (0.0078617)*
SNK	0.0723269 (0.0048497)*	0.0652191 (0.0199245)*	0.0888393 (0.0198349)*	0.0242004 (0.0078617)*	-0.869278 (0.0330284)*
Households with children and a full-time employed single woman, 1992					
FAFH	-0.297904 (0.06751)*	0.236203 (0.033552)*	0.325203 (0.0436343)*	0.454094 (0.0661023)*	0.333563 (0.0485852)*
FAH	-0.0503 (0.0022529)*	-1.00144 (0.0208992)*	-0.0642234 (0.0091181)*	-0.076229 (0.0097057)*	-0.0620595 (0.0093902)*
COV	-0.30781 (0.0184056)*	-0.277377 (0.0289736)*	-1.29783 (0.0439455)*	-0.42602 (0.0341747)*	-0.337657 (0.0300424)*
MEAL	-0.0370711 (0.0070133)*	-0.0559638 (0.0098137)*	0.0034253 (0.0319762)	0.0034253 (0.0319762)	-0.0415245 (0.0075704)*
SNK	0.242923 (0.0154022)*	0.261431 (0.0556801)*	0.325904 (0.0551709)*	-0.0415245 (0.0075704)*	-0.603975 (0.057941)*

*Statistically significant at the 5% critical level.

Chapter 7 Summary and Recommendations

7.1 Summary

The purpose of this study was to explore Canadian household expenditures for major food categories using both single equation and demand system approaches incorporating correction for selection bias. We started with a review of demand studies on various food categories. We also reviewed relevant studies on cross-sectional demand estimation with zero expenditure and correction of sample selection bias. The approach to incorporating socioeconomic and demographic variables into demand estimation and the collective setting of household behavior is also investigated.

In the second stage of the research, we organized and summarized the Canadian Family Food Expenditure Survey data for 1986 and 1992. The data were divided and aggregated into five major categories to obtain basic expenditure pattern information. Detailed food items were then aggregated for later use in the estimation stage. We found that the expenditure share of food-away-from-home, convenience food and snacks increased by 2% to 5% from 1986 to 1992, the share of food-at-home decreased by 8%, and the share of prepared meals remained unchanged.

To investigate the major demand determinants of Canadian household expenditures on foods, variables including price, income, and other socioeconomic and demographic characteristics were incorporated into demand models based on household production theory. Both single equation and demand system models were estimated incorporating correction for sample selection bias. Using disaggregated household data, the price adjustment processes are necessary at the first step for demand estimations. The adjustment process was conducted using OLS with combinations of using the inverse Mill ratios and regional dummies. Results from this study suggest that different adjustment approaches do not necessary lead to significant variations in the adjusted prices and the final-stage demand estimates, however, price adjustment is still needed to preclude collinearity problem which can be generated when using unit values from the data.

In the single equation approach, models for each food category were estimated separately. The sample selection bias resulting from zero expenditure problems of the data were corrected using Heckman's two-stage procedure. We found that more than two-thirds of the coefficients were statistically significant.

In the demand system approach, an Almost Ideal Demand System (the AIDS model) was estimated by using seemingly unrelated regression estimation (SURE) and three stage least square (3SLS) estimation method. Selection bias was also corrected by incorporating the inverse Mills ratios obtained from the probit models for each expenditure category into each equation of the system. Demand constraints (e.g. adding up, homogeneity and symmetry) were imposed during this demand system estimation. Most of the coefficients obtained from the system were statistically significant at the 5% or 10% critical level. Correction for selection bias is advised, as suggested by the statistical significance of the inverse Mills ratio in both single equation and demand system applications. The major determinants of five food categories include employment status, gender, marital status, immigrant arrival years of the household manager, presence of children and number of full time earners in household, as well as the residing area and size of the family.

Evidence of structural change in demand in the period 1986 to 1992 was found using the Chow (1960) tests for the single equation demand functions. The test results rejected the hypothesis that coefficients from 1986 and 1992 data are identical, suggesting that the structural changes occurred in this six-year period.

The calculation of elasticities of price and socioeconomic variables requires consideration of the selection process (the effect of the inverse Mills ratio on demand). This approach differs from the traditional approach common in the literature. It appears that using expenditure or quantity as a dependent variable in single demand functions leads to the similar elasticities, as the only condition is using log prices as independent variables instead of using linear forms. Although the single equation and demand system models have different function forms, the elasticities calculated from either approach do not exhibit much difference in direction. However, the elasticities from the system approach provide slightly larger values.

The estimated elasticities indicate that the Canadian food demand categories are not very elastic with respect to price changes. Price elasticity for food-away-from-home is smaller than other categories. Food demand is also inelastic with respect to household income, but relatively more responsive to total food expenditures. The total food expenditure elasticities are generally larger than one while income elasticities are smaller than one. The elasticity estimates are basically consistent with the results of previous studies using Canadian data. Compared to the studies based on US data, we obtained slightly larger income elasticities and smaller family size elasticities for FAFH.

To investigate the "collective" behavior of intra-household allocations on food expenditure decisions, the data were divided into several sub-samples according to the employment and marital status of the female household member. We estimated and compared the difference in elasticities for these sub-samples from both the single equation and demand system approach. A Chow (1960) test of structural change was also used in the single-equation sub-sample estimations to investigate the similarity of parameter estimates consistency of coefficients from different sub-samples. Most of the results from these procedures indicate that households with a married woman generally have lower price elasticities on FAFH, but higher elasticities on FAH than single woman households. The Chow (1960) tests results also rejected the hypothesis that coefficients of different sub-samples are similar. These results suggest that the intra-household allocation may have a strong effect on a family's consumption decisions on food.

7.2 Marketing Implications

The findings of this study may be useful to food producers and merchandisers including restaurants, fast-food franchisers, food processing and retail food industries. The food-away-from-home providers (for example, restaurants, fast food outlets, retail stores, etc.) may wish to concentrate marketing efforts on male headed, young, higher educated, single person households to maintain or further expand their sales. For regional FAFH providers who want to expand their national business, Ontario and Alberta could be the first places to consider because of the strong household preference for food-away-from home in these provinces. Among the different seasons, summer and early autumn should be considered as the best time to maximize sales by the FAFH marketers. Because the income elasticities for FAFH expenditure (0.45–0.54 in this study) are relatively larger than elasticities with respect to other socioeconomic variables, the promotion target for the FAFH marketers could be focused on households with high income levels. The low price elasticities (absolute values smaller than 0.7) of FAFH generally indicate that a slight increase in FAFH prices will not hurt sales much. However, according to the price elasticities we obtained from this study, FAFH marketers may expect a greater decrease in the number of single female buyers than married female customers because of the larger price elasticities of the former. To explore more market potential and drive possible demand shifts, the FAFH providers may also wish to attract new immigrants to build up initial confidence in related products. Based on the information in this study, it appears that immigrants' demand for FAFH may grow after they have settled in Canada for a while.

For the food processing industry and other at-home-food producers, the increasing percentage of convenience food and snack consumption within household food budgets suggests a new direction for production. The quality, packaging and promotion of convenience food products should be oriented towards the needs of full-time working, female-headed, middle-aged, large-sized, and married-couple households. The advertisement of convenience food products towards households with children may increase the expenditure share, but may not effectively expand the expenditure on convenience foods. The first quarter seems to be the preferred season for convenience food; hence, promotion at that time may bring expansion of sales. Households in the Atlantic region have a strong preference for convenience food. Although the market size of these provinces is not large, food processors may still want to pay some attention by targeting marketing efforts there. The relatively high price elasticities for prepared meals merits caution about any changes in price. Moreover, the higher expenditure elasticities indicate that both the processing industry and retail food industry should take a close look at consumers' disposable expenditure for food.

For the retail food industry, consumers' increasing interests in convenience food and snacks may bring more business to retailers. Retail stores may focus their convenience foods and snacks marketing efforts on full-time working, male, married, middle aged with children and large family customers. Education levels have opposite effects on convenience food and snacks consumption, so retail marketers may need to diversify their promotion strategies when their target involves highly educated people. Ontario and Alberta are the two most important regions for marketing snacks. To expand the annual sales potential, the second quarter (April to June) of the year may be the best season to promote snacks.

7.3 Contributions

This thesis made three major contributions. The first contribution of this study is that it is one of the first systematic studies on household demand for main food categories such as food-away-from-home, food-at-home, convenience foods, prepared meals, and snacks, using single equation and demand system approaches corrected for selection bias. Most previous studies only employed the single equation approach to investigate the demand for one food category. The only researcher who investigated demand for food-away-from-home, food-at-home and prepared foods as a system is Nayga (1996). However, in Nayga's (1996) study price information was absent. As prices are imperative in demand analysis, his results may be biased. This thesis explicitly classified five food categories with a demand system approach and estimated price elasticities for every food category. It is found that the estimation results are different from those of the single equation approach in several aspects. The implication is that one need to be cautious regarding the results from the single equation application.

The second contribution of this study is that it examined the intra-household allocation of household's decision on food expenditures by applying a sub-sample grouping method. Though the data limits our application to investigate the intra-household behavior, the results indicate that the intra-household allocation could be an important factor in household demand for food. Our empirical experience also raised further attention to collective models of household behavior as well as the need to include detailed income information in survey data.

The third contribution of this thesis is that it is the first study applying the demand system approach to Canadian household survey data. Results from system estimations provided a thorough understanding of Canadian household demand for food when all the categories are considered simultaneously. This study also allows us to understand whether Canadians behave different from Americans on food expenditures.

7.4 Limitations and Recommendations for Future Studies

A limitation of this study is that the definitions of food-away-from-home, food-at-home, convenience food, prepared meals and snacks are not very stringent. The rough aggregation of different food items under these categories may not accurately reflect consumers' interpretation of these classifications. Hence, detailed research on a particular food item may better estimate the demand relationships, both theoretically and empirically. In another aspect, research on a particular region (for example, the province of Alberta) may lead to a more thorough and interesting understanding of food consumption in a region by ruling out any unrelated information.

The price adjustment process using the linear regression model is another limitation of this study. Although the adjusted prices from different models do not present large discrepancies, the explanatory ability (R^2) of the linear model is relatively low. This suggests that unknown variables should be included to make the price adjustment model more accurate. Because the FFES data only provide income information on every household instead of individuals inside the family, an examination of intra-household allocation theory (collective model approach) can only be achieved by estimating sub-sample data and making comparisons. For future studies on this theory applied to food consumption, modeling approaches should be based on household data with better income information.

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Appendix 1 Elasticity Formulas

Considering marginal effects from the selection process (Saha et al 1997), we derived the uncompensated own price elasticities for single equation demand function with expenditure as the dependent variables as follows:

For Engle expenditure equation:

$$E_i = \alpha_0 + \alpha_1 p'_i + \alpha_{IMR} * IMR \quad \text{(A1.1)}$$

$$p_i q_i = \alpha_0 + \alpha_1 p'_i + \alpha_{IMR} * IMR \quad \text{(A1.2)}$$

where E_i, pi and qi are the expenditure, price and quantity for the *i*th food category; and IMR is the inverse Mills ratio from the probit estimation.

Take derivative of E_i with respect to p_i to obtain marginal effect:

$$\frac{\partial E_i}{\partial p_i} = q_i + p_i \frac{\partial q_i}{\partial p_i} = \alpha_1 \frac{\partial p'_i}{\partial p_i} + \alpha_{IMR} * \frac{\partial IMR}{\partial P_i} = ME_p \text{ (Marginal Effect)} \quad \text{(A1.3)}$$

$$p_i \frac{\partial q_i}{\partial p_i} = \alpha_1 \frac{\partial p'_i}{\partial p_i} + \alpha_{IMR} * \frac{\partial IMR}{\partial P_i} - -q_i \quad \text{(A1.4)}$$

$$\frac{p_i}{q_i} \frac{\partial q_i}{\partial p_i} = \left[\alpha_1 \frac{\partial p'_i}{\partial p_i} + \alpha_{IMR} * \frac{\partial IMR}{\partial P_i} - -q_i \right] \Big/ q_i \quad \text{(A1.5)}$$

because

$$\alpha_1 \frac{\partial p'_i}{\partial p_i} + \alpha_{IMR} * \frac{\partial IMR}{\partial p_i} = ME \quad \text{(A1.6)}$$

$$\varepsilon_{ii} = ME_p / q_i - 1 \quad \text{(A1.7)}$$

If we use the logarithmic form for estimation,

$$E_i = \alpha^*_0 + \alpha^*_1 \ln p_i' + \alpha^*_{IMR} * IMR \quad \text{(A1.8)}$$

$$\frac{\partial E_i}{\partial \ln p_i} = \alpha^*_1 \frac{\partial \ln p_i'}{\partial \ln pi} + \alpha^*_{IMR} * \frac{\partial IMR}{\ln p_i} = ME_{\ln p} \text{ (Marginal Effect using log form)} \quad \text{(A1.9)}$$

$$\frac{\partial p_i q_i}{\frac{\partial p_i}{p_i}} = \alpha^*_1 \frac{\partial \ln p_i'}{\partial \ln pi} + \alpha^*_{IMR} * \frac{\partial IMR}{\ln p_i} \quad \text{(A1.10)}$$

$$\frac{p_i \partial q_i + q_i \partial p_i}{\frac{\partial p_i}{p_i}} = \alpha^*_1 \frac{\partial \ln p_i'}{\partial \ln pi} + \alpha^*_{IMR} * \frac{\partial IMR}{\ln p_i} \quad \text{(A1.11)}$$

$$p_i^2 \frac{\partial q_i}{\partial p_i} + p_i q_i = ME_{\ln p} \quad \text{(A1.12)}$$

$$\varepsilon_{ii} + 1 = ME_{\ln p} / E_i \quad \text{(A1.13)}$$

$$\varepsilon_{ii} = ME_{\ln p} / E_i - 1 \quad \text{(A1.14)}$$

Because $ME_{lnp} = \frac{\partial E_i}{\partial \ln p_i} = \frac{\partial E_i}{\partial p_i / p_i}$, $\quad ME_{\ln p} / E_i = \frac{\partial E_i}{\partial p_i / p_i} \Big/ p_i q_i = \frac{\partial E_i}{\partial p_i} \Big/ q_i = ME_p / q_i$

$$\varepsilon = ME_{\ln p} / E_i - 1 = ME_p / q_i - 1 \qquad \text{(A1.15)}$$

Hence regardless of whether we use a linear or log form, the own price elasticities can be derived from both forms and these are mathematically equivalent. The cross price elasticities can be derived in the same way and it is not discussed in detail.

The elasticities of demand with respect to the socioeconomic variables for the single equation demand function can be derived as follows:

For the Engle expenditure equation:

$$E_i = \alpha_0 + \alpha_1 \ln p'_i + b\Psi_i + \beta_{IMR} * IMR \qquad \text{(A1.16)}$$

where ψ_i is the socioeconomic-demographic variable of interest, including income and household size, education etc.

The derivative of E_i with respect to ψ_i yields the marginal effect.

$$ME_\psi = \frac{\partial E_i}{\partial \Psi_i} = b + \beta_{IMR} * \frac{\partial IMR}{\partial \Psi_i} \qquad \text{(A1.17)}$$

Since ψ_i is not a component of E_i, simply multiply $\frac{\Psi_i}{E_i}$ by ME_ψ, to obtain the elasticities of demand (expenditure) with respect to socio-demographic variables:

$$\eta = \frac{\partial E_i}{\partial \Psi_i} \cdot \frac{\Psi_i}{E_i} = ME_\psi \cdot \frac{\Psi_i}{E_i} = (b + \beta_{IMR} * \frac{\partial IMR}{\partial \Psi_i}) * \frac{\Psi_i}{E_i} \qquad \text{(A1.18)}$$

Appendix 2 Classification of Food Categories by Item Code

Table A2-1 Detailed Convenience Food Items and Codes

Detailed convenience food items	code	Detailed convenience food items	code
Bacon	170	Bread	300
Ham (ex. Cooked ham)	171	Unsweetened rolls & buns	301
Other cured meat	173	Canned pasta products	310
Uncooked sausage	180	dry or fresh pasta	311
Bologna	181	Pasta mixes	312
Weiners	182	Breakfast cereal	295
Other cooked/cured sausage	183	Potato products	433
Cooked (boiled) ham	184	Baked beans	451
Other ready-cooked meat	185	Canned soup	540
Other meat preparations	186	Dried soup	541
Hams	190	Canned infant or junior foods	550
Other canned meat & meat prep.	192	Infant cereals & biscuits	551
Cured fish	220	Infant formula	552
Salmon	230	Other pre-cooked food preparations	563
Tuna	231	Other pre-cooked food preparations	563
Other canned fish	232		

Table A2-2 Detailed Snack Items and Codes

Detailed snack items	code	Detailed snack items	code
Yogurt	265	Other dried/preserved fruit	1352
Ice cream & ice milk	275	Apple juice	360
Ice cream or ice milk novelties	276	Grapefruit juice	361
Crackers & crisp breads	302	Orange juice	362
Doughnuts	304	Other fruit juice	363
Yeast-raised sweet goods	305	Orange juice	370
Dessert pies, cakes & other pastries	306	Other fruit juice	371
Other bakery products	307	Peaches	381
Cake & other flour-based mixes	296	Pineapple	383
Other cereal grain products	297	Mixed fruit	384
Apples	320	Other canned fruit	1385
Bananas & plantains	321	Jam, jelly & other preserves	386
Grapefruit	323	Fruit pie fillings	387
Grapes	324	Unshelled nuts	390
Lemons & limes	325	Shelled peanuts	391
Melons	326	Other shelled nuts	392
Oranges & other citrus fruit	327	Tomato juice	460
Peaches & nectarines	328	Other canned vegetable juice	461
Pears	329	Dessert pies, cakes, other pastries	561
Plums	330	Potato chips	589
Other tropical fruit	331	Canned puddings & custards	591
Strawberries	333	Carbonated beverages	600
Other fresh fruit	1334	Fruit drinks	601
Frozen fruit	1341	Other non-alcoholic beverages	602
Raisins	351		

Table A2-3 Detailed Food-At-Home Items and Codes

Detailed FAH items	Code	Detailed FAH items	Code
Beef		Other dairy products	282
Hip cuts (excluding shank cuts)	100	Eggs	285
Loin cuts	101	Cereal grains and other cereal products	
Rib cuts	102	Rice (including mixes)	290
Chuck cuts (excluding shank cuts)	103	Flour	291
Stewing beef	104	Other grains, unmilled or milled	294
Ground beef (including patties)	105	Vegetables	
Carcasses and primal portions	106	Green or wax beans	400
All other (including brisket, shank)	107	Broccoli	401
Pork		Cabbage	403
Leg cuts (excluding hocks)	130	Carrots	404
Loin cuts	131	Cauliflower	405
Belly cuts	132	Celery	406
Shoulder cuts (excluding hocks)	133	Corn	407
Carcasses and primal portions	134	Cucumbers	408
All other (including hocks)	135	Lettuce	409
Other fresh or frozen meat		Mushrooms	410
Veal	110	Onions	411
Lamb and mutton	120	Peppers	412
Liver	140	Potatoes	413
Other offal	141	Radishes	414
Other meat (excluding poultry)	150	Spinach	415
Fresh or frozen poultry meat		Tomatoes	416
Chicken (including fowl)	160	Turnips and rutabagas	417
Turkey	161	Other seed and gourd vegetables	418
Other poultry meat and offal	162	Other root vegetables	419
Fish		Other leaf and stalk vegetables	420
Cod	200	Frozen vegetables	
Flounder and sole	201	Corn	431
Haddock	202	Peas	432
Salmon	205	Potato products	433
Other sea fish	206	Other frozen vegetables	434
Freshwater fish	207	Condiments, spices and vinegar	1470
Shrimps and prawns	240	Fats and oils	1530
Other shellfish	241	Other foods, materials and food prep.	1540
All other marine products	250	Materials for food preparations	570

Table A2-4 Detailed Prepared Meal Items and Codes

Detailed prepared meal items	code	Detailed prepared meal items	code
Meat stews	191	Pre-cooked frozen dinners	560
Pre-cooked frozen fish portions	210	Frozen meat or poultry pies	562

Table A2-5 Detailed Food-Away-From-Home Category *

Table service	Eat-in or drive-in fast food	Fast food take-out
Breakfast	Breakfast	Breakfast
Lunches	Lunches	Lunches
Dinners	Dinners	Dinners
Between meals	Between meals	Between meals
Cafeteria	Other restaurants	
Breakfast	Breakfast	
Lunches	Lunches	
Dinners	Dinners	
Between meals	Between meals	

*no item codes were recorded for FAFH in FFES data file .

Appendix 3 Probit Estimation Results

Table A3-1 Probit Estimation Results 1986

	fafh	*t-ratio*	*fah*	*t-ratio*	*cov*	*t-ratio*	*meal*	*t-ratio*	*snk*	*t-ratio*
FULLEMPL	7.43E-02	1.35	2.81E-02	0.287	1.55E-02	0.188	1.01E-01	1.913*	-1.17E-03	-0.014
NOEMPL	-3.40E-01	-5.563*	-1.77E-01	-1.802*	-1.88E-01	-2.222*	-3.36E-02	-0.492	-1.72E-01	-1.993*
URBAN	1.37E-02	0.283	-3.14E-02	-0.344	4.58E-02	0.612	1.07E-01	2.112*	3.68E-02	0.48
SEX	-2.41E-01	-3.33	-9.29E-02	-0.679	1.77E-01	1.619**	-2.06E-02	-0.257	2.83E-02	0.239
MARRIED	-6.52E-02	-0.195	5.85E+00	0.0001	6.08E+00	0.0013	7.86E-02	0.248	6.07E+00	0.0002
WW	-2.33E-01	-3.314*	-1.78E-01	-1.327	9.24E-02	0.869	1.30E-03	0.017	-1.25E-01	-1.079
AGE	-1.10E-02	-8.409*	5.85E-03	2.726*	9.24E-03	5.066*	1.02E-03	0.756	7.12E-03	3.746*
CHILDREN	-1.93E-01	-3.392*	4.52E-02	0.395	-7.89E-02	-0.867	-6.27E-02	-1.14	-1.57E-01	-1.742*
NFEARNER	5.62E-02	1.466	1.91E-02	0.284	2.43E-03	0.042	3.28E-03	0.094	2.37E-02	0.388
INCOME	1.04E-05	8.975*	-3.26E-06	-2.166*	-3.31E-06	-2.568*	-2.24E-06	-2.345*	-1.63E-06	-1.122
HSIZE	1.92E-02	0.875	4.74E-02	1.049	2.44E-02	0.65	1.08E-01	5.319*	7.23E-02	1.773*
ARRIVAL	-2.28E-02	-2.022*	-4.53E-03	-0.197	-4.69E-03	-0.258	-1.67E-02	-1.434	-7.85E-03	-0.4
Q1	8.45E-02	2.006*	1.36E-01	1.745**	2.28E-01	3.52	8.42E-02	2.028*	2.15E-01	3.176*
Q2	1.41E-01	3.317*	2.90E-02	0.386	6.41E-02	1.042	-7.40E-03	-0.175	5.18E-02	0.805
Q3	2.00E-03	0.048	-2.45E-01	-3.541*	-1.40E-01	-2.4	-7.79E-02	-1.815*	-1.68E-01	-2.752*
GC1	-2.85E-01	-5.225*	1.24E-02	0.125	1.10E-01	1.356	4.37E-01	8.025*	-5.98E-03	-0.069
GC2	-1.59E-01	-2.897*	6.24E-02	0.633	1.34E-01	1.659**	-6.84E-02	-1.192	-2.69E-04	-0.003
GC3	-6.13E-02	-1.16	-1.69E-01	-1.898*	-2.62E-02	-0.356	2.13E-01	4.063*	-1.76E-01	-2.188*
GC4	-1.31E-01	-2.238*	-1.37E-01	-1.404	-1.12E-01	-1.413	1.15E-01	1.929*	-1.42E-01	-1.63**
GC5	-3.79E-02	-0.574	-1.12E-01	-1.025	-1.13E-01	-1.303	3.19E-02	0.488	-2.74E-01	-2.951*
EDU2	1.98E-01	4.855*	1.98E-01	2.781*	1.40E-01	2.236*	7.58E-02	1.652**	1.56E-01	2.44*
EDU3	5.96E-01	9.724*	4.57E-01	4.276*	3.67E-01	4.109*	9.81E-02	1.627**	4.70E-01	4.966*
EDU4	5.27E-01	8.551*	3.16E-01	3.072*	2.94E-01	3.298*	7.00E-02	1.148	2.89E-01	3.182*
EDU5	5.58E-01	8.594*	4.95E-01	4.454*	3.49E-01	3.839*	2.50E-02	0.4	5.29E-01	5.246*
HC1	1.25E-01	1.016	-2.77E-01	-1.589	-4.91E-01	-3.185*	5.49E-02	0.478	-3.04E-01	-1.933*
HC2	1.11E-01	0.35	-5.56E+00	3.17E-04	-5.92E+00	1.78E-03	-7.44E-03	-0.025	-5.77E+00	2.17E-04
HC3	8.62E-02	0.277	-5.47E+00	1.25E-04	-5.67E+00	1.13E-03	-2.96E-02	-0.099	-5.66E+00	7.02E-04
HC4	2.61E-02	0.081	-5.59E+00	1.14E+02	-5.70E+00	3.90E-04	-1.01E-01	-0.329	-5.84E+00	5.21E-04
HC6	-9.29E-02	-0.749	8.04E-04	0.005	-1.54E-01	-0.991	1.02E-01	0.87	-1.57E-01	-0.998
HC7	-1.68E-01	-1.203	2.43E-01	1.096	9.21E-02	0.489	-1.19E-01	-0.86	3.11E-02	0.167

*Statistically significant at 5% critical level.
** Statistically significant at 10% critical level.

Table A3-2 Probit Estimation Results 1992

	FAFH	*t-ratio*	*FAH*	*t-ratio*	*COV*	*t-ratio*	*MEAL*	*t-ratio*	*SNK*	*t-ratio*
WEUROPE	-3.54E-03	-0.04	1.10E-01	0.695	3.23E-01	2.213*	1.46E-02	0.151	1.54E-01	1.073
SEUROPE	-3.89E-01	-3.68*	2.04E-02	0.114	3.84E-02	0.241	-2.37E-01	-1.985*	-4.40E-02	-0.273
ASIA	-2.04E-01	-1.326	-4.92E-02	-0.198	1.17E-01	0.528	-3.70E-01	-2.25*	-1.40E-01	-0.62
OTHERN	-3.29E-01	-2.22*	-7.70E-02	-0.318	4.17E-02	0.195	-3.58E-01	-2.203*	-3.68E-02	-0.163
FULLEMPL	4.17E-02	0.715	9.85E-03	0.103	-1.23E-01	-1.469	-9.09E-02	-1.734**	3.53E-02	0.415
NOEMPL	-3.13E-01	-6.705*	-9.26E-02	-1.16	-9.46E-02	-1.383	-1.80E-02	-0.383	-3.52E-02	-0.497
URBAN	5.15E-03	0.114	-4.37E-02	-0.547	-4.70E-02	-0.693	1.06E-01	2.33*	-7.70E-03	-0.112
SEX	4.23E-02	1.155	1.57E-01	2.794*	8.87E-02	1.825**	-1.33E-02	-0.367	1.99E-01	3.924*
MARRIED	1.47E-01	3.293*	4.65E-01	6.303*	4.29E-01	6.765*	-9.22E-03	-0.208	4.93E-01	7.427*
WW	-2.84E-02	-0.441	1.97E-01	1.745**	-2.23E-02	-0.24	-3.63E-02	-0.651	1.28E-01	1.303
AGE	-1.05E-02	-8.013*	6.40E-03	3.091*	6.68E-03	3.771*	5.20E-04	0.401	4.35E-03	2.335*
CHILDREN	-1.85E-01	-3.275*	6.22E-02	0.602	7.45E-02	0.871	1.37E-01	2.691*	1.69E-02	0.189
NFEARNER	5.54E-02	1.273	-2.27E-02	-0.309	8.35E-02	1.277	7.09E-02	1.832*	-2.03E-02	-0.311
INCOME	8.50E-06	9.555*	-6.36E-07	-0.543	4.79E-07	0.452	-8.39E-08	-0.125	4.75E-07	0.428
HSIZE	-4.32E-02	-2.499*	6.94E-02	2.189*	8.65E-02	3.214*	5.60E-02	3.556*	7.72E-02	2.755*
ARRIVAL	-1.90E-02	-1.074	-1.25E-02	-0.433	-3.30E-02	-1.286	6.25E-03	0.338	-6.28E-03	-0.235
Q1	1.82E-02	0.423	5.45E-02	0.76	8.45E-02	1.387	1.87E-03	0.046	1.10E-01	1.744**
Q2	-1.77E-02	-0.415	4.19E-02	0.585	4.83E-02	0.799	-6.91E-02	-1.688**	1.26E-01	1.967*
Q3	-1.44E-02	-0.34	-1.70E-01	-2.55*	-1.55E-01	-2.719*	-9.64E-02	-2.351*	-1.36E-01	-2.318*
GC1	-4.41E-01	-8.661*	7.46E-02	0.983	1.32E-01	2.032*	2.96E-01	6.126*	2.32E-02	0.338
GC2	-2.58E-01	-4.608*	6.31E-01	6.188*	5.36E-01	6.698*	5.58E-02	1.049	4.68E-01	5.467*
GC3	-1.93E-01	-3.666*	1.18E-02	0.161	1.58E-01	2.44*	1.43E-01	2.893*	9.34E-03	0.138
GC5	-2.35E-01	-3.466*	1.49E-02	0.156	-2.09E-03	-0.026	-6.06E-02	-0.923	-2.60E-02	-0.297
GC6	-8.29E-02	-1.269*	4.50E-01	4.041*	3.74E-01	4.233*	-6.18E-02	-0.99	3.30E-01	3.455*
EDU2	1.92E-01	4.522*	2.15E-01	2.926*	1.34E-01	2.075*	1.31E-01	2.717*	1.62E-01	2.503*
EDU3	4.52E-01	7.525*	2.51E-01	2.561*	1.57E-01	1.873*	1.11E-01	1.826*	2.82E-01	3.178*
EDU4	5.07E-01	8.892*	3.01E-01	3.203*	1.83E-01	2.288*	1.52E-01	2.663*	2.88E-01	3.438*
EDU5	5.14E-01	7.522*	2.48E-01	2.428*	2.37E-01	2.611*	3.58E-02	0.548	3.48E-01	3.634*

*Statistically significant at 5% critical level.
** Statistically significant at 10% critical level.

Appendix 4 Single Equation Estimates of Model 2 and Model 3

Table A4-1 Estimated Coefficients of Single Demand Equation for FAFH

	1986					*1992*			
	Model2		*Model3*			*Model2*		*Model3*	
	coefficient	t-ratio	coefficient	t-ratio		coefficient	t-ratio	coefficient	t-ratio
					WEUROPE	8.4755994	1.292	8.7042672	1.321
					SEUROPE	4.4412081	0.512	5.1162763	0.589
					ASIA	39.041229	3.693*	39.54658	3.725*
					OTHERN	9.799572	0.892	10.741075	0.975
FULLEMPL	-0.281617129	-0.101	-0.278096234	-0.1	FULLEMPL	-9.1710072	-2.538*	-9.3942895	-2.586*
NOEMPL	8.387872797	1.712*	8.466682864	1.724*	NOEMPL	1.5356263	0.338	2.007653	0.445
URBAN	2.950896231	1.072	2.946011916	1.069	URBAN	4.8558729	1.558	4.8279555	1.542
SEX	-13.97911469	-2.86*	-13.83234252	-2.825*	SEX	-11.266436	-4.526*	-11.35558	-4.541*
MARRIED	-33.28571817	-1.856*	-33.20707366	-1.849*	MARRIED	2.3432692	0.748	2.1841404	0.696
WW	-2.793735318	-0.589	-2.675406313	-0.563	WW	-5.3854126	-1.412	-5.5063039	-1.437
AGE	1.42E-02	0.157	1.65E-02	0.183	AGE	0.131945	1.172	0.1423232	1.269
CHILDREN	-10.42721542	-3.396*	-10.38765643	-3.376*	CHILDREN	-6.6529953	-2.109*	-6.655543	-2.1*
NFEARNER	4.641623005	2.445*	4.636273547	2.439*	NFEARNER	12.753336	4.61*	12.737309	4.585*
INCOME	6.03E-04	10.516*	6.01E-04	10.452*	INCOME	5.54E-04	9.276*	5.49E-04	9.234*
HSIZE	-0.575770738	-0.507	-0.571311807	-0.502	THS	-2.1037259	-1.535	-2.1287452	-1.546
ARRIVAL	0.771117329	1.264	0.777057637	1.271	ARRIVAL	-1.6166768	-1.313	-1.6340847	-1.321
Q1	-2.302703164	-1.018	-2.311536696	-1.021	Q1	1.2990629	0.464	0.3388153	0.121
Q2	-1.709888089	-0.737	-1.685543507	-0.725	Q2	0.9481878	0.339	1.9996665	0.718
Q3	7.589268488	3.322*	5.779865028	2.547*	Q3	8.2463914	2.969*	10.552481	3.784*
GC1	2.72572341	0.845	2.068531731	0.637	GC1	-1.0148937	-0.232	0.8325642	0.189
GC2	7.035671249	2.387*	8.807496194	2.974*	GC2	3.9885749	1.058	11.993845	3.233*
GC3	4.948207001	1.762*	2.792884043	1.031	GC3	5.2155268	1.534	7.516755	2.199*
GC4	2.713762686	0.857	4.626663294	1.48	GC5	9.8775681	2.237*	12.658292	2.896*
GC5	9.384080811	2.848*	8.933980419	2.706*	GC6	-1.4891409	-0.374	4.7033302	1.193
EDU2	-4.542936232	-1.47	-4.567166703	-1.475	EDU2	1.928414	0.454	1.4407706	0.34
EDU3	-11.6676047	-2.398	-11.74580859	-2.408*	EDU3	4.262588	0.711	3.3292932	0.56
EDU4	-10.02154255	-2.158*	-10.07641033	-2.164*	EDU4	4.1592785	0.692	3.275807	0.55
EDU5	-2.255407917	-0.473	-2.34125506	-0.49	EDU5	5.2711326	0.843	4.4073569	0.71
HC1	-8.672717918	-1.473	-8.584266154	-1.456					
HC2	15.23297428	0.88	15.2347277	0.878					
HC3	12.36491053	0.725	12.32677218	0.722					
HC4	13.18372716	0.751	13.16424986	0.748					
HC6	-9.604933803	-1.564	-9.526770693	-1.549					
HC7	-8.697001352	-1.203	-8.56460083	-1.183					
PFAFH	57.62092871	16.742*	58.00966198	16.719*	PFAFH	47.9071	17.86*	44.779499	17.374*
PFAH	5.36167016	0.894	5.733122967	0.953	PFAH	4.0033008	0.85	3.6237421	0.799
PCOV	-1.821627979	-0.447	-2.028014734	-0.475	PCOV	14.326507	3.332*	14.17665	3.2*
PMEAL	4.606001546	0.918	4.171373161	0.772	PMEAL	8.1650726	1.256	7.3312063	1.169
PSNK	12.77441697	3.313*	12.77661127	3.336*	PSNK	19.738359	4.217*	19.079174	4.185*
LAMBDA	-60.71000488	-4.482*	-61.16125857	-4.497*	LAMBDA	-52.032285	-2.648*	-55.496829	-2.876*

*Statistically significant at 5%-10% critical level.

1986:
Model2: R-squared = .192122, Adjusted R-squared = .18828 Model test: F [37, 7777] = 49.99
Model3: R-squared = .191777, Adjusted R-squared = .18793 Model test: F [37, 7777] = 49.87

1992:
Model2: R-squared = .161067, Adjusted R-squared = .15761 Model test: F [35, 8490] = 46.57,
Model3: R-squared = .161080, Adjusted R-squared = .15762 Model test: F [35, 8490] = 46.58

Table A4-2 Estimated Coefficients of Single Demand Equation for FAH

	1986					*1992*			
	Model2		*Model3*			*Model 2*		*Model 3*	
	Coefficient	t-ratio	coefficient			coefficient	t-ratio	Coefficient	t-ratio
					WEUROPE	0.9753621	0.256	1.0133087	0.265
					SEUROPE	13.729794	3.025*	13.75264	3.017*
					ASIA	-1.2325766	-0.198	-1.2022962	-0.192
					OTHERN	1.5528738	0.25	1.5988459	0.256
FULLEMPL	2.22859547	1.16	2.229833695	1.156	FULLEMPL	-4.230802	-1.913*	-4.2526285	-1.914*
NOEMPL	-11.06690124	-4.22*	-11.16565324	-4.282*	NOEMPL	-7.7984781	-4.005*	-7.8220582	-4.001*
URBAN	0.847873498	0.465	0.830958741	0.453	URBAN	3.5726796	1.941*	3.5681228	1.93
SEX	0.356083929	0.123	0.31966073	0.114	SEX	2.7612588	1.694*	2.7766946	1.697*
MARRIED	10.04831103	0.893	10.45380051	0.842	MARRIED	22.562896	8.131*	22.630386	8.129*
WW	-2.86529434	-0.967	-2.947646787	-1.016	WW	-1.6760945	-0.697	-1.6732352	-0.694
AGE	0.572440003	10.587*	0.575049134	10.60*	AGE	0.6135336	10.364*	0.6143597	10.338*
CHILDREN	-13.53518681	-6.781*	-13.52492702	-6.756*	CHILDREN	-1.7198611	-0.905	-1.7205665	-0.902
NFEARNER	9.64E-02	0.075	0.10529846	0.082	NFEARNER	1.2947501	0.782	1.2997086	0.781
INCOME	2.39E-04	6.691*	2.38E-04	6.639*	INCOME	2.09E-04	7.556*	2.09E-04	7.524*
HSIZE	16.5186711	20.841*	16.53555864	20.87*	HSIZE	15.943223	19.058*	15.945479	18.989*
ARRIVAL	0.767922954	1.879*	0.764541189	1.861*	ARRIVAL	1.97216	2.72	1.9644449	2.697*
Q1	-1.471711271	-0.93	-1.422269151	-0.896	Q1	0.4255003	0.253	0.2104694	0.125
Q2	-2.108932889	-1.385	-2.034637369	-1.332	Q2	0.6135062	0.366	0.8957391	0.536
Q3	-4.675099825	-2.368*	-5.603264425	-2.955*	Q3	-6.0155949	-3.312*	-5.9702255	-3.294*
GC1	-2.14843304	-1.086	-2.904389777	-1.477	GC1	7.9122132	3.909*	8.1552114	4.046*
GC2	10.179444	5.119*	10.05547537	5.081*	GC2	22.353163	7.424*	22.698456	8.111*
GC3	-7.461846198	-3.453*	-7.48226469	-3.696*	GC3	4.0546373	2.018*	4.3323628	2.152*
GC4	-11.51115293	-5.285*	-11.20628597	-5.079*	GC5	3.4930177	1.342	3.6656066	1.419
GC5	-3.122155062	-1.333	-2.777360136	-1.184	GC6	11.22487	3.817*	12.039779	4.281*
EDU2	-0.695883638	-0.37	-0.602158116	-0.319	EDU2	4.8072908	2.286*	4.8399524	2.292*
EDU3	0.330628076	0.116	0.512133308	0.178	EDU3	6.8098376	2.588*	6.8339537	2.586*
EDU4	2.657360164	1.024	2.796926689	1.071	EDU4	8.87718	3.454*	8.9122174	3.453*
EDU5	2.626432051	0.864	2.846355162	0.93	EDU5	12.391418	4.451*	12.435702	4.448*
HC1	-9.454351533	-2.095*	-9.617966271	-2.122*					
HC2	-0.938592829	-0.088	-1.222311551	-0.104					
HC3	6.601355389	0.633	6.348958427	0.551					
HC4	5.402277752	0.497	5.125265348	0.431					
HC6	-0.37839243	-0.09	-0.372009394	-0.088					
HC7	2.372143449	0.48	2.494140057	0.499					
PFAFH	6.346451389	3.555*	6.43302904	3.574*	PFAFH	4.3976759	3.103*	4.0312905	3.103*
PFAH	11.73541315	3.085*	11.59618216	3.022*	PFAH	6.1116399	2.124*	5.9953377	2.152*
PCOV	8.770028064	3.198*	8.888564974	3.093*	PCOV	5.7056601	2.366*	5.6185364	2.253*
PMEAL	-5.753520489	-1.611	-6.385381793	-1.66*	PMEAL	-4.71915	-1.179	-4.8410446	-1.259
PSNK	3.410268465	1.321	3.323565245	1.29	PSNK	4.0950532	1.432	3.9069864	1.403
LAMBDA	34.77187043	1.114	37.73685476	1.201	LAMBDA	79.070842	2.945*	79.938202	2.972*

*Statistically significant at 5%-10% critical level.

1986
Model2: R-squared =. 304040, Adjusted R-squared =. 30140, Model test: F [37, 9754] = 115.17
Model3: R-squared =. 303999, Adjusted R-squared =. 30136, Model test: F [37, 9754] = 115.14
1992
Model2: R-squared = .277942, Adjusted R-squared = .27548 Model test: F [35,10247] =112.70,
Model3: R-squared = .277892, Adjusted R-squared = .27543 Model test: F [35,10247] =112.67

Table A4-3 Estimated Coefficients of Single Demand Equation for COV

	1986					*1992*			
	Model 2		*Model 3*			*Model2*		*Model3*	
	Coefficient	t-ratio	coefficient	t-ratio		coefficient	t-ratio	coefficient	t-ratio
					WEUROPE	0.6800731	0.456	0.7710293	0.518
					SEUROPE	1.0171812	0.606	1.0447089	0.622
					ASIA	-12.319489	-5.336*	-12.282618	-5.324*
					OTHERN	-6.4772662	-2.824*	-6.4410722	-2.81*
FULLEMPL	2.0508317	3.291*	2.046747	3.273*	FULLEMPL	0.7134582	0.856	0.6816477	0.819
NOEMPL	-2.2464028	-2.636*	-2.2979554	-2.689*	NOEMPL	-2.2309401	-3.057	-2.260371	-3.1
URBAN	-0.3360179	-0.566	-0.328006	-0.552	URBAN	0.4235509	0.619	0.4170318	0.61
SEX	-1.6468987	-1.709*	-1.5936666	-1.658*	SEX	-0.3128256	-0.536	-0.2895371	-0.497
MARRIED	2.9867423	0.733	3.2267639	0.83	MARRIED	4.2091782	3.422*	4.3466035	3.529*
WW	-0.1960239	-0.217	-0.1710442	-0.189	WW	-1.5617887	-1.815*	-1.5705903	-1.826*
AGE	8.25E-02	3.763*	8.51E-02	3.877*	AGE	8.35E-02	3.405*	8.54E-02	3.48*
CHILDREN	-2.255572	-3.482*	-2.2641308	-3.487*	CHILDREN	3.768174	5.218*	3.7888082	5.249*
NFEARNER	-1.1355153	-2.738*	-1.1321594	-2.721*	NFEARNER	-0.4477746	-0.721*	-0.428557	-0.69
INCOME	5.22E-05	4.324*	5.15E-05	4.26*	INCOME	5.83E-05	5.689*	5.82E-05	5.683*
HSIZE	6.4216412	25.312*	6.4291587	25.323*	HSIZE	7.3878123	23.332*	7.3999275	23.387*
ARRIVAL	-0.1371848	-1.038	-0.1385963	-1.046	ARRIVAL	0.1605125	0.586	0.1495472	0.546
Q1	0.2364232	0.414	0.2846664	0.498	Q1	-0.219623	-0.348	-0.5221635	-0.825
Q2	-0.4118272	-0.826	-0.3744123	-0.749	Q2	-0.9577729	-1.542	-1.1322854	-1.83
Q3	-0.4749496	-0.81	-0.8486836	-1.504	Q3	-0.9454132	-1.346	-1.1284223	-1.626
GC1	0.1176692	0.181	-0.2054701	-0.315	GC1	-0.6691283	-0.867	-1.0240806	-1.319
GC2	0.6492409	0.945	0.6650017	0.972	GC2	-1.4951698	-1.155	-1.3967024	-1.175
GC3	0.1471523	0.228	0.1801196	0.296	GC3	4.31E-02	0.053	7.74E-02	0.096
GC4	-0.3633954	-0.499	-0.4440145	-0.606	GC5	0.9612263	0.999	1.0721688	1.127
GC5	1.2229125	1.566	1.367583	1.766*	GC6	-1.2555846	-1.056	-0.6747012	-0.607
EDU2	-0.3758533	-0.648	-0.3375286	-0.581	EDU2	-0.7175427	-0.949	-0.6848848	-0.906
EDU3	-1.4038258	-1.558	-1.3140145	-1.457	EDU3	-2.39E-02	-0.025	-2.33E-03	-0.002
EDU4	-0.8764841	-1.032	-0.8021725	-0.944	EDU4	1.0926358	1.184	1.1305669	1.225
EDU5	-2.0723102	-2.264*	-1.9739036	-2.155*	EDU5	1.1850476	1.113	1.2400517	1.164
HC1	0.6847566	0.403	0.5201615	0.305					
HC2	-0.1794587	-0.047	-0.3754399	-0.102					
HC3	3.0075755	0.808	2.8594062	0.801					
HC4	-0.3753449	-0.098	-0.5269636	-0.143					
HC6	2.3184458	1.651*	2.2728372	1.616					
HC7	2.4881307	1.574	2.5189915	1.592					
PFAFH	1.3041667	2.422*	1.2973756	2.394*	PFAFH	0.8360303	1.563	0.7511638	1.529
PFAH	2.4494578	1.769*	2.6050346	1.875*	PFAH	1.1973472	1.164	1.223414	1.236
PCOV	5.9452033	5.896*	5.967295	5.732*	PCOV	7.994419	7.995*	7.9895342	7.855*
PMEAL	-3.760409	-3.214*	-4.0887948	-3.243*	PMEAL	-2.3532752	-1.591	-2.4910968	-1.76*
PSNK	1.6944374	1.973*	1.672159	1.951*	PSNK	1.4980147	1.361	1.3943789	1.304
LAMBDA	3.1915481	0.369	4.5378533	0.525	LAMBDA	-3.1413746	-0.313	-1.8429315	-0.183

*Statistically significant at 5%-10% critical level.

1986
Model2: R-squared = .310012, Adjusted R-squared =. 30733 Model test: F [37, 9524] =115.65
Model3: R-squared = .309790, Adjusted R-squared = .30711 Model test: F [37, 9524]= 115.53
1992
Model2: R-squared =. 276832, Adjusted R-squared = .27431 Model test: F [35, 10028] = 109.68
Model3: R-squared =. 276593, Adjusted R-squared = .27407 Model test: F [35, 10028] = 109.55

Table A4-4 Estimated Coefficients of Single Demand Equation for MEAL

	1986					*1992*			
	Model 2		*Model3*			*Model 2*		*Model3*	
	Coefficient	t-ratio	coefficient	t-ratio		coefficient	t-ratio	coefficient	t-ratio
					WEUROPE	-0.4943927	-0.266	-0.4950898	-0.383
					SEUROPE	4.238464	1.113	3.0450691	1.142
					ASIA	3.5421596	0.645	1.6652807	0.436
					OTHERN	5.9197578	1.037	3.9970722	1.001
FULLEMPL	-6.85E-03	-1.294	-8.65E-03	-1.332	FULLEMPL	1.4521105	0.812	0.8937819	0.709
NOEMPL	-7.48E-04	-0.166	-1.52E-05	-0.003	NOEMPL	-0.2911088	-0.32	-0.3645572	-0.576
URBAN	-3.28E-03	-0.615	-5.08E-03	-0.779	URBAN	-1.032041	-0.688	-0.5610375	-0.534
SEX	-2.26E-03	-0.444	-1.89E-03	-0.307	SEX	0.2995935	0.387	0.1745317	0.322
MARRIED	3.35E-03	0.175	3.62E-04	0.015	MARRIED	-0.372473	-0.44	-0.3077224	-0.524
WW	-1.49E-03	-0.307	-1.49E-03	-0.252	WW	0.4691543	0.356	0.1863482	0.202
AGE	7.12E-05	0.798	5.32E-05	0.484	AGE	-1.48E-03	-0.052	3.91E-03	0.198
CHILDREN	4.30E-03	1.04	5.35E-03	1.055	CHILDREN	-1.9807993	-0.875	-1.1482607	-0.726
NFEARNER	2.14E-03	1.025	2.07E-03	0.804	NFEARNER	-1.0949272	-0.776	-0.6441281	-0.648
INCOME	3.97E-08	0.325	8.56E-08	0.573	INCOME	1.18E-05	0.925	1.24E-05	1.389
HSIZE	-6.85E-03	-1.517	-8.77E-03	-1.572	HSIZE	-4.62E-02	-0.11	3.77E-02	0.13
ARRIVAL	-5.05E-04	-0.503	-2.20E-04	-0.181	ARRIVAL	7.87E-02	0.217	0.1178261	0.467
Q1	1.84E-03	0.537	7.93E-04	0.188	Q1	-0.3965212	-0.524	-0.4169384	-0.795
Q2	2.38E-03	0.828	2.87E-03	0.822	Q2	0.8932439	0.563	-0.2762495	-0.339
Q3	3.95E-03	0.806	4.22E-03	0.817	Q3	0.9172886	0.603	0.2776056	0.273
GC1	-1.88E-02	-1.077	-2.61E-02	-1.225	GC1	-4.2986083	-1.295	-3.5230883	-1.385
GC2	-2.95E-03	-0.593	-4.24E-03	-0.833	GC2	-3.5870338	-1.438	-0.7570866	-1.005
GC3	-6.00E-03	-1.063	-1.46E-02	-1.243	GC3	-2.3497259	-1.128	-1.4657061	-1.091
GC4	-7.09E-03	-0.767	-5.05E-03	-0.646	GC5	0.898892	0.707	2.0140107	1.946*
GC5	-4.47E-03	-1.073	-6.62E-03	-1.195	GC6	5.95E-02	0.05	1.1455946	1.13
EDU2	1.37E-04	0.031	-1.35E-03	-0.248	EDU2	-2.1676824	-1.233	-1.5776752	-1.286
EDU3	-1.33E-03	-0.249	-3.14E-03	-0.476	EDU3	-2.0215633	-1.182	-1.5219703	-1.277
EDU4	-1.84E-03	-0.398	-3.04E-03	-0.534	EDU4	-2.3568615	-1.135	-1.6563845	-1.142
EDU5	-6.02E-04	-0.15	-1.30E-03	-0.263	EDU5	-0.8868535	-0.686	-0.7352836	-0.82
HC1	1.81E-02	2.398*	1.72E-02	1.871*					
HC2	-6.62E-03	-0.363	-4.98E-03	-0.222					
HC3	-7.60E-03	-0.427	-5.57E-03	-0.253					
HC4	-2.71E-03	-0.147	1.69E-04	0.007					
HC6	2.66E-03	0.316	7.60E-04	0.074					
HC7	8.83E-03	0.902	1.11E-02	0.925					
PFAFH	-3.72E-03	-1.32	-3.28E-03	-0.931	PFAFH	0.7155454	0.812	0.3917342	0.7
PFAH	4.09E-03	0.515	2.29E-03	0.239	PFAH	-1.0394612	-0.736	-0.8574242	-0.896
PCOV	-1.36E-02	-1.307	-1.77E-02	-1.355	PCOV	-0.4731859	-0.252	0.1820674	0.137
PMEAL	4.36E-02	1.192	6.18E-02	1.344	PMEAL	15.958187	1.418	11.157112	1.441
PSNK	3.46E-03	0.556	1.40E-03	0.187	PSNK	0.445166	0.312	0.2179677	0.228
LAMBDA	-4.60E-02	-0.881	-6.93E-02	-1.078	LAMBDA	-17.692986	-1.123	-11.355076	-1.029

*Statistically significant at 5%-10% critical level.

1986
Modle2: R-squared = .161068, Adjusted R-squared = .14358, Model test: F [37, 1775] = 9.21
Model3: R-squared = .161688, Adjusted R-squared = .14421, Model test: F [37, 1775] = 9.25
1992
Model2: R-squared = .072566, Adjusted R-squared = .05485 Model test: F [35, 1832] = 4.10
Model3: R-squared = .071436, Adjusted R-squared = .05370 Model test: F [35, 1832] = 4.03,

Table A4-5 Estimated Coefficients of Single Demand Equation for Snack

	1986					*1992*			
	Model2		*Model3*			*Model2*		*Model3*	
	Coefficient	t-ratio	Coefficient	t-ratio		coefficient	t-ratio	coefficient	t-ratio
					WEUROPE	-0.8756472	-0.458	-0.8560188	-0.448
					SEUROPE	4.2846475	1.888*	4.3165896	1.901*
					ASIA	-9.7813694	-3.132*	-9.7590952	-3.123*
					OTHERN	-2.4266652	-0.788	-2.3833584	-0.774
FULLEMPL	3.2075223	4.224*	3.2044628	4.225*	FULLEMPL	1.1362672	1.022	1.1299092	1.016
NOEMPL	-2.2797025	-2.222*	-2.2859201	-2.243*	NOEMPL	-3.5758661	-3.715*	-3.5738464	-3.711*
URBAN	0.4807537	0.67	0.4828066	0.673	URBAN	0.203025	0.221	0.2004851	0.218
SEX	0.4148562	0.37	0.4211437	0.379	SEX	2.7709662	3.104*	2.7704135	3.104*
MARRIED	11.210578	2.49*	11.266563	2.494*	MARRIED	9.0804037	5.571*	9.0770056	5.574*
WW	-0.479565	-0.428	-0.4766039	-0.429	WW	1.905215	1.588	1.9003511	1.584
AGE	0.190229	8.131*	0.190654	8.468*	AGE	0.3718893	12.784*	0.3717172	12.774*
CHILDREN	-3.4597195	-4.273*	-3.4638021	-4.286*	CHILDREN	5.0419188	5.308*	5.0486047	5.313*
NFEARNER	-0.6597382	-1.303	-0.659516	-1.302	NFEARNER	-1.4719086	-1.773*	-1.4811075	-1.783*
INCOME	1.20E-04	8.855*	1.20E-04	8.887*	INCOME	1.36E-04	9.834*	1.36E-04	9.891*
HSIZE	5.2088749	16.194*	5.2123919	16.336*	HSIZE	8.5115321	19.711*	8.5096152	19.702*
ARRIVAL	0.4132932	2.557*	0.4125722	2.551*	ARRIVAL	0.9570451	2.66*	0.953202	2.648*
Q1	-1.0853603	-1.69*	-1.0787012	-1.692*	Q1	-1.510464	-1.742*	-1.6494764	-1.904*
Q2	0.5536128	0.922	0.6075628	1.012	Q2	1.3258231	1.526	1.2731161	1.463
Q3	5.92E-02	0.083	-0.4815613	-0.699	Q3	-2.0780164	-2.281*	-2.4722365	-2.737*
GC1	1.2583695	1.602	0.9300117	1.193	GC1	0.9834233	0.993	0.9625106	0.98
GC2	6.4239663	8.136*	6.0598087	7.771*	GC2	8.2455048	5.396*	9.1315744	6.422*
GC3	1.7319766	2.084*	1.9746532	2.533*	GC3	3.1383252	3.16*	3.36656	3.393*
GC4	-1.0210595	-1.149	-0.6300577	-0.708	GC5	2.4631531	1.92*	3.3993253	2.673*
GC5	2.8360052	2.791*	3.3225701	3.312*	GC6	1.4078556	0.961	2.9293769	2.091*
EDU2	1.5805949	2.263*	1.5886456	2.304*	EDU2	2.9802745	2.844*	2.9843056	2.847*
EDU3	3.3936484	3.038*	3.4092571	3.127*	EDU3	5.4316392	3.888*	5.4199388	3.878*
EDU4	4.0493554	4.061*	4.0610194	4.14*	EDU4	7.5117324	5.566*	7.503944	5.559*
EDU5	6.6012164	5.571*	6.6265743	5.731*	EDU5	10.317313	6.658*	10.312609	6.653*
HC1	0.6235015	0.344	0.6113491	0.337					
HC2	-4.7436691	-1.095	-4.7851769	-1.099					
HC3	-1.1600437	-0.275	-1.1978486	-0.281					
HC4	-5.3285151	-1.217	-5.3703042	-1.215					
HC6	3.5362516	2.081*	3.5326557	2.072*					
HC7	4.6654991	2.455*	4.674621	2.456*					
PFAFH	0.9597251	1.438	0.9861788	1.475	PFAFH	0.9882928	1.427	0.9340993	1.47
PFAH	6.6412633	4.312*	6.7236932	4.363*	PFAH	4.8219432	3.408*	4.7415662	3.485*
PCOV	3.8881444	3.716*	3.9463432	3.6*	PCOV	7.6622953	6.54*	7.6565002	6.349*
PMEAL	-1.8056009	-1.278	-2.0109301	-1.329	PMEAL	0.1024621	0.051	0.1168006	0.061
PSNK	8.3443243	8.053*	8.2778008	8.039*	PSNK	13.930541	8.671*	13.616478	8.695*
LAMBDA	16.694514	1.785*	16.87226	1.875*	LAMBDA	21.709576	1.6	21.84594	1.614

*Statistically significant at 5%-10% critical level.

1986

Model2: R-squared = .270858, Adjusted R-squared = .26803 Model test: F [37, 9556] = 95.94

Model3: R-squared = .270780, Adjusted R-squared = .26796 Model test: F [37, 9556] = 95.90

1992

R-squared = .283739, Adjusted R-squared = .28126 Model test: F [35, 10105] = 114.37

R-squared = .283719, Adjusted R-squared = .28124 Model test: F [35, 10105] = 114.36

Appendix 5 System Estimations with SURE

Table A5-1 System Estimations with SURE – 1986

	FAFH	*t-ratio*	*FAH*	*t-ratio*	*COV*	*t-ratio*	*Meal*	*t-ratio*	*Snack*	*t-ratio*
Constant	1.02E+00	95.01*	9.76E-01	294.96*	8.57E-01	201.30*	2.10E-01	8.11*	8.95E-01	203.27*
COUNTRY	-4.15E-02	-34.59*	3.68E-03	10.01*	8.30E-04	1.75**	5.09E-03	1.74	5.35E-03	10.87*
FULLEMPL	2.01E-02	8.03*	3.40E-03	4.44*	7.68E-04	0.77	-7.19E-03	-1.17	1.41E-03	1.38
NOEMPL	-1.75E-01	-56.10*	-2.39E-02	-25.02*	-2.85E-02	-23.04*	3.32E-02	4.36*	-3.15E-02	-24.63*
URBAN	3.11E-02	13.13*	-1.89E-04	-0.26	5.87E-03	6.26*	-3.21E-03	-0.55	7.00E-03	7.22*
SEX	-9.10E-02	-24.69*	-1.29E-02	-11.40*	1.33E-02	9.14*	4.82E-02	5.35*	-1.73E-03	-1.15
MARRIED	2.36E-02	1.48	2.03E-02	4.16*	3.78E-02	5.98*	2.93E-02	0.75	4.49E-02	6.87*
WW	-8.08E-02	-22.54*	-2.40E-02	-21.88*	-2.31E-03	-1.62	1.50E-02	1.71**	-2.33E-02	-15.85*
AGE	-2.96E-03	-48.03*	3.03E-04	16.02*	8.76E-04	35.84*	2.52E-05	0.17	6.72E-04	26.60*
CHILDREN	-5.02E-02	-19.19*	3.19E-03	3.98*	3.59E-05	0.04	2.02E-02	3.17*	-8.84E-03	-8.25*
NFEARNER	4.48E-02	29.02*	-6.60E-04	-1.40	-7.25E-04	-1.19	-1.50E-02	-3.98*	1.51E-03	2.39*
HSIZE	7.23E-03	7.06*	1.47E-03	4.69*	4.47E-03	11.00*	-1.36E-02	-5.44*	5.95E-03	14.17*
ARRIVAL	-5.39E-03	-10.10*	-3.65E-04	-2.23*	-1.66E-04	-0.78	-1.10E-03	-0.84	-1.15E-03	-5.26*
Q1	1.17E-02	5.91*	8.08E-03	13.36*	1.92E-02	24.57*	7.64E-03	1.58	1.38E-02	17.03*
Q2	3.07E-02	15.48*	1.17E-03	1.93*	4.58E-03	5.84*	-2.47E-03	-0.51	-1.36E-04	-0.17
Q3	7.94E-04	0.40	-1.81E-02	-29.47*	-1.60E-02	-20.15*	-1.57E-02	-3.20*	-1.99E-02	-24.19*
GC1	-9.77E-02	-38.02*	-4.26E-04	-0.54	9.02E-03	8.86*	3.59E-03	0.57	-5.39E-03	-5.13*
GC2	-5.81E-02	-22.48*	1.43E-03	1.80**	1.32E-02	12.88*	-1.08E-02	-1.7**	2.56E-03	2.42*
GC3	-2.00E-02	-7.93*	-1.26E-02	-16.36*	-3.48E-03	-3.49*	-1.20E-02	-1.95*	-1.66E-02	-16.06*
GC4	-4.94E-02	-17.86*	-1.09E-02	-12.94*	-1.86E-02	-17.03*	6.13E-03	0.91	-2.14E-02	-18.91*
GC5	-1.29E-02	-4.34*	-7.57E-03	-8.32*	-1.33E-02	-11.32*	-2.76E-02	-3.79*	-2.79E-02	-22.90*
EDU2	3.06E-02	14.33*	1.17E-03	1.79**	1.07E-03	1.27	-6.93E-04	-0.13	3.27E-03	3.75*
EDU3	4.48E-02	15.81*	1.26E-03	1.45	5.04E-04	0.45	3.96E-03	0.57	4.51E-03	3.89*
EDU4	5.30E-02	18.61*	2.07E-03	2.38*	2.24E-03	1.99*	-1.28E-02	-1.8**	5.63E-03	4.84*
EDU5	8.18E-02	29.20*	3.20E-03	3.73*	1.32E-03	1.19	-1.42E-02	-2.08*	9.24E-03	8.06*
HC1	2.49E-02	4.69*	-2.86E-02	-17.54*	-4.29E-02	-20.35*	1.09E-02	0.84	-2.87E-02	-13.18*
HC2	1.34E-02	0.87	-3.29E-03	-0.70	-3.40E-03	-0.56	-1.89E-03	-0.05	2.18E-03	0.35
HC3	-6.02E-03	-0.40	3.77E-03	0.82	8.38E-03	1.40	-1.17E-02	-0.32	6.27E-03	1.01
HC4	1.35E-02	0.87	1.33E-03	0.28	3.74E-03	0.61	-2.24E-02	-0.59	4.55E-03	0.71
HC6	-3.83E-03	-0.70	2.90E-03	1.73**	2.82E-03	1.30	-2.16E-04	-0.02	-5.78E-05	-0.03
HC7	-2.13E-03	-0.34	4.38E-03	2.27*	5.52E-03	2.21*	7.78E-03	0.51	6.37E-03	2.47
PFAFH	-8.91E-03	-4.35*	4.56E-04	0.73	1.72E-03	2.13*	-3.87E-02	-7.78*	7.13E-04	0.86
PFAH	1.96E-02	3.94*	-1.09E-03	-0.72	3.98E-03	2.02*	-3.55E-02	-2.91*	3.93E-03	1.92**
PCOV	3.16E-03	0.89	-5.62E-04	-0.52	-2.52E-03	-1.79**	-3.33E-02	-3.82*	-4.38E-04	-0.30
PMEAL	-2.78E-03	-0.61	3.83E-04	0.27	6.19E-04	0.34	-3.68E-03	-0.33	4.17E-04	0.22
LNTFE	7.95E-03	9.36*	5.13E-04	1.86**	-2.51E-04	-0.73	1.48E-01	77.34*	-5.37E-04	-1.50
LAMDA	5.63E-01	49.54*	4.44E-01	85.52*	4.78E-01	89.27*	3.44E-03	21.34*	4.78E-01	89.79*

*statically significant at the 5% critical level.
* statically significant at the 10% critical level.

Table A5-2 System Estimations with SURE – 1992

	FAFH	t-ratio	FAH	t-ratio	COV	t-ratio	meal	t-ratio	snk	t-ratio
WEUROPE	-4.14E-03	-0.33	1.90E-03	0.2	4.36E-03	0.805	6.45E-04	0.681	-2.71E-03	-0.421
SEUROPE	-5.34E-02	-3.565*	3.23E-02	2.852*	4.60E-03	0.712	-2.05E-03	-1.82**	1.26E-02	1.638
ASIA	2.35E-02	1.143	2.27E-02	1.458	-3.33E-02	-3.758*	-2.85E-03	-1.836*	-2.60E-02	-2.463*
OTHERN	-3.71E-02	-1.814*	4.66E-02	3.014*	-1.95E-02	-2.217*	-1.55E-03	-1.007	-3.87E-03	-0.369
FULLEMPL	-1.16E-02	-1.579	2.56E-03	0.462	2.13E-03	0.673	-1.43E-03	-2.585*	8.60E-03	2.285*
NOEMPL	-4.18E-02	-6.59*	1.70E-02	3.548*	7.79E-03	2.847*	-1.50E-04	-0.313	6.25E-03	1.92
URBAN	1.45E-02	2.382*	-3.68E-03	-0.8	-7.68E-03	-2.925*	1.10E-03	2.387*	-8.40E-03	-2.689*
SEX	-2.97E-02	-6.08*	1.94E-02	5.266*	-2.29E-03	-1.086	-8.97E-04	-2.434*	1.59E-02	6.341*
MARRIED	-4.77E-02	-8.033*	4.75E-02	10.561*	8.06E-03	3.134*	-2.18E-03	-4.871*	1.26E-02	4.106*
WW	-2.78E-02	-3.583*	1.05E-02	1.788**	-2.35E-03	-0.701	-1.01E-03	-1.72**	1.83E-02	4.6*
AGE	-2.84E-03	-16.278*	1.78E-03	13.514*	3.25E-05	0.431	2.21E-05	1.68**	1.09E-03	12.173*
CHILDREN	-5.94E-02	-9.382*	1.24E-02	2.582*	2.08E-02	7.623*	1.98E-03	4.148*	2.44E-02	7.509*
NFEARNER	5.01E-02	9.531*	-2.14E-02	-5.378*	-9.42E-03	-4.156*	1.06E-03	2.673*	-1.66E-02	-6.145*
HC	-6.50E-03	-3.794*	8.56E-03	6.603*	1.49E-03	2.012*	-2.09E-04	-1.615	-7.64E-04	-0.869
HSIZE_	-2.60E-02	-9.453*	1.24E-02	5.955*	9.13E-03	7.682*	-2.66E-04	-1.282	6.87E-03	4.86*
ARRIVAL	-6.51E-03	-2.725*	5.60E-03	3.106*	-6.68E-04	-0.649	5.99E-05	0.333	2.95E-03	2.412*
Q1	-2.51E-03	-0.451	1.08E-02	2.558*	2.89E-03	1.203	-1.42E-04	-0.338	-5.78E-03	-2.024*
Q2	4.11E-03	0.74	3.60E-03	0.859	-3.04E-03	-1.269	-8.36E-04	-1.997	2.80E-03	0.982
Q3	2.05E-02	3.707*	-1.66E-02	-3.969*	-5.71E-03	-2.396*	-9.59E-04	-2.3	-9.18E-03	-3.236*
GC1	-6.42E-02	-9.767*	5.32E-02	10.722*	2.19E-03	0.773	1.88E-03	3.805*	1.45E-02	4.312*
GC2	-5.60E-02	-7.954*	6.46E-02	12.126*	-9.90E-03	-3.259*	3.61E-04	0.679	3.02E-02	8.359*
GC3	-1.53E-02	-2.347*	1.32E-02	2.684*	-4.94E-03	-1.76**	1.24E-03	2.525*	8.95E-03	2.676*
GC5	-7.42E-03	-0.875	6.61E-03	1.032	-3.49E-03	-0.954	4.20E-05	0.066	1.03E-02	2.358*
GC6	-2.05E-02	-2.555*	3.85E-02	6.328*	-3.30E-03	-0.951	-6.02E-05	-0.099	3.02E-03	0.731
EDU2	2.44E-02	3.839*	-2.69E-03	-0.561	-1.07E-02	-3.923*	1.13E-03	2.368*	3.09E-03	0.948
EDU3	5.78E-02	7.148*	-2.19E-02	-3.588*	-2.20E-02	-6.323*	7.03E-04	1.155	1.32E-03	0.318
EDU4	5.41E-02	7.118*	-2.47E-02	-4.301*	-1.89E-02	-5.761*	1.40E-03	2.449*	5.41E-03	1.384
EDU5	6.57E-02	7.918*	-2.69E-02	-4.286*	-2.69E-02	-7.514*	-4.07E-04	-0.65	4.06E-03	0.951
LNFAFH1	8.41E-02	15.523*	-3.90E-02	-9.534*	-1.92E-02	-8.214*	-1.52E-03	-3.731*	-2.93E-02	-10.54*
LNFAH1	1.03E-02	0.992	4.99E-03	0.639	-1.35E-02	-3.028*	-4.72E-04	-0.605	-4.57E-03	-0.862
LNCOV1	4.29E-02	4.888*	-4.95E-02	-7.463*	8.74E-03	2.312*	5.42E-04	0.82	-3.98E-03	-0.884
LNMEAL1	1.56E-02	1.743**	-6.17E-03	-0.913	-1.24E-02	-3.213*	-2.44E-03	-3.621*	-3.61E-03	-0.785
LNSNK1	3.51E-02	3.752*	-5.62E-02	-7.956*	-2.48E-02	-6.161*	-1.48E-03	-2.098*	4.01E-02	8.377*
LNTFE1	4.03E-02	15.906*	-2.44E-02	-12.20*	-1.43E-02	-11.94*	-1.49E-03	-7.856*	-1.36E-02	-9.582*
LAMDA	4.02E-02	25.13*	13.01E-02	47.188*	5.62E-02	32.165*	2.04E-02	91.39*	7.49E-02	35.993*

*statistically significant at the 5% critical level.

**statistically significant at the 10% critical level

Appendix 6 List of Household Description Variables

household composition
total household size
total adults 65 and over
total adults 45 to 64 years
total adults 25 to 44 years
total adults 18 to 24 years
total adults 16 to 17 years
total children 5 to 15 years
total children < 5 years
number of persons at home
number of full-time earners
number of part-time earners
number of economic families
number of unemployment insurance recipients
social assistance indicator
income before taxes
income from wages and salaries
income from self-employment
income from investment
income from government transfer payments
income from other sources
income not stated indicator
meals received free or reimbursed:
while on trips overnight or longer
locally and on day trips
total meals received free or reimbursed
meals served to guests
value of food not purchased

Appendix 7 Definitions of the Explanatory Variables

FULLEMPL:	Dummy variable for household head who works full time (=1, 0 otherwise)
NOEMPL:	Dummy variable for household head who is not employed (=1, 0 otherwise)
URBAN:	Dummy variable for household head who is resides in urban area (=1, 0 otherwise)
SEX:	Gender of household head (male=0, female=1)
MARRIED:	Dummy variable for the married household head (=1, 0 otherwise)
WWOMEN:	Dummy variable for the working woman, either full or part time (=1, 0 otherwise)
AGE:	Age of the household head (=Actual age)
CHILDREN:	Presence of Children dummy (=1, 0 otherwise)
NFEARNER:	Number of full-time earner(=Actual number)
INCOME:	Income before tax (=actual income)
HSIZE:	Household size (total household size, =number of people in the household)
ARRIVAL:	Immigrant arrival years (1= Canadian born, 2= Before 1946, 3= 1946-55, 4= 1956-60 5= 1961-65 6=1966-70, 7=1971-75, 8=1976-80, 9=1981-85, 10=1986-92)
Q1:	Seasonal/Quarterly dummy, first quarter (January-March)=1, 0 otherwise
Q2:	Seasonal/Quarterly dummy, second quarter (April-June)=1, 0 otherwise
Q3:	Seasonal/Quarterly dummy, third quarter (July-September)=1, 0 otherwise
GC1:	Regional dummy, Atlantic province (=1, 0 otherwise)
GC2:	Regional dummy, Province of Quebec (=1, 0 otherwise)
GC3:	Regional dummy, Province of Ontario (=1, 0 otherwise)
GC4:	Regional dummy, Province of Manitoba and Saskatchewan (=1, 0 otherwise)
GC5:	Regional dummy, Province of Alberta (=1, 0 otherwise)
EDU2:	Educational dummy household head, Some or completed secondary education (=1, 0 otherwise)
EDU3:	Educational dummy for household head, Some post-secondary education (=1, 0 otherwise)
EDU4:	Educational dummy for household head, Post-secondary certificate or diploma (=1, 0 otherwise)
EDU5:	Educational dummy for household head, University degree (=1, 0 otherwise)
HC1:	Household composition dummy, one person household (=1, 0 otherwise)
HC2:	Household composition dummy, married couple household (=1, 0 otherwise)
HC3:	Household composition dummy, married couple with single children household (=1, 0 otherwise)
HC4:	Household composition dummy, married couple with at least one relative household (=1, 0 otherwise)
HC6:	Household composition dummy, other household with relative only (=1, 0 otherwise)
HC7:	Household composition dummy, other non-married-couple household (=1, 0 otherwise)
PFAFH:	Log prices of food-away-from-home = (log of actual price index after adjusted)
PFAH:	Log prices of food-at-home = (log of actual price index after adjusted)
PCOV:	Log prices of convenience food = (log of actual price index after adjusted)
PMEAL:	Log prices of prepared meals = (log of actual price index after adjusted)
LAMBDA:	Inverse Mills ratio.