The Demand for Processed Meat in Canada: An Application of the Almost Ideal Demand System

BY

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ABSTRACT

The objective of this research is to conduct an econometric analysis of Canada's demand for processed meat based on panel data. The four meat categories included in the system of equations used in the estimation are fresh and frozen beef, pork, and poultry as well as processed meat. The random effect panel method was estimated by generalized least squares (GLS) and the complete demand system with a linear approximation of an almost ideal demand system (LA/AIDS). The expenditure elasticity of processed meat was estimated to be positive but not with much confidence which suggests processed meat (as defined by Statistics Canada's Survey of Household Spending) may a normal good. The Marshallian own-price elasticities estimated using two methods were at -.568 and -.976 with some confidence suggesting a tax to lower processed meat consumption may need to be relatively high to reduce consumption. Some evidence was identified that the consumption of processed meat causes health costs. Processed meat, beef and pork are estimated to be mild substitutes as measured by their substitution elasticities. This study shows that the Canadian consumption of processed meat is comparable to other meats but the demand needs to be further investigated before recommendations regarding a processed meat tax are made.

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AIDS – Almost Ideal Demand System

BMI – Body Mass Index

CANSIM – Canadian Socio-Economic Information Management System

CHD – Coronary Heart Disease

CPI – Consumer Price Index

FAO – Food and Agriculture Organization of the United Nations

FE – Fixed Effect

GLS – Generalized Least Square

IARC – International Agency for Research on Cancer

ITSUR – Iterative Seemingly Unrelated Regression

LA/AIDS – Linear Approximation of the Almost Ideal Demand System

LM – Breusch-Pagan Lagrange Multiplier

OLS – Ordinary Least Square

QUAID – Quadratic Almost Ideal Demand System

RE – Random Effect

SHS – Survey of Household Spending

US – United States of America

WC – Waist Circumference

WHO – World Health Organization

CHAPTER 1
INTRODUCTION

1.1 Introduction

In Canada, meat is available in various forms: fresh, frozen and processed. Processed meat made up 38% of the meat consumed by Canadians in 2016 (Statistics Canada, 2017). Processed meat can be considered as an alternative for fresh meat products. In recent years, consumers have been increasing their demand for ready-to-eat and ready-to-cook meat products (Government of Canada, 2010). Processed meat is not only convenient to consumers but it is also profitable for producers and processors due to a reduction in waste of animal tissues by maximizing the use of edible livestock parts (Heinz & Hautzinger, 2007).

The World Health Organisation (WHO) (2015) considers processed meat as any meat that has been changed through processing method(s) such as smoking, curing, fermenting, drying, canning and salting to either expand its conservation and/or improve its taste. Freezing is not considered a processing method. The Food and Agriculture Organization of the United Nations (FAO) (Heinz & Hautzinger, 2007) identifies six categories of processed meat products. The first category includes fresh processed meat products such as hamburgers, fired sausage, kebab and chicken nuggets. The second category includes cured meat pieces such as raw cured beef, raw ham, cooked beef, cooked ham, and bacon. The third category includes raw-cooked products such as frankfurters, mortadella, lyoner and meat-loaf. Precooked meat that still needs to be cooked, such as liver sausage, blood sausage and corned beef constitute the fourth category. Raw (dry) – fermented sausage including salami and some traditional Asian products constitute the fifth category. The final category includes dried meat such as dried meat strips or flat pieces (biltong, beef jerkey, etc.) and meat floss.

The Statistic Canada definition of processed meat includes bacon, uncooked ham, dinner ham, sausage, wieners, deli and deli-style meat and other meat preparations such as canned meat or meat stew. Processed meat products differ from fresh or frozen meats as the animal tissues have been physically and chemically modified. Processed meats can contain a wide range of substances of non-meat origin such as chemical substances or plant-origin substances. Non-meat ingredients either have functional properties or serve to add volume. Some functional properties include taste, flavor, appearance, color and texture. Chemical substances which have functional properties can only be used if safe for consumers. However, the use of chemical additives must be limited: salt content is limited to 2% or 4% depending on the processing method, other chemical substances are limited to 1% of content except nitrates with a limit of 0.05% (Heinz & Hautzinger, 2007).

High consumption of processed meat products increases the consumption of chemical substances, including potentially carcinogenic substances like nitrates (Bouvard et al., 2015). Therefore, depending on the level of consumption and the form of the product consumed, consumption of processed meat products can have some repercussions on the health of the consumers and their health care costs.

1.2 Motivation

The consumption of meat products has been linked to positive and negative health outcomes, increased body weight and increased risk of cardiovascular disease and increase risk of cancer. There is no agreement or certainty on the role of meat consumption in becoming overweight or obese (Togo et al., 2001) but researchers have linked consumption of meat to higher intake of total calories, higher intake of total fat and reduction in vegetables consumption (Nicklas et al., 1995; Leitzmann, 2005). Furthermore, the association between meat consumption and obesity using body mass index (BMI) and waist circumference (WC) among US adults was studied by Wang and Beydoun (2009) where nationally representative data were used in linear and logistic regression analysis to test the association between meat consumption and adiposity measures. The research concluded, based on the US national cross-sectional data, that there is a positive association between meat consumption and risk for obesity.

There are some observational studies that analyze the association of red and processed meats with obesity since red meat and processed meat are a rich source of nutrient and protein, but also contain saturated fatty acid and cholesterol (Schulze et al., 2003; Wyness et al., 2011). To determine the nature of the connection between a high-protein diet rich in red meat and meat products and obesity, Rouhani et al. (2014) searched various databases for observational studies on the relationship between red and processed meat intake and obesity. The research led to a systematic review of 21 studies and a meta-analysis of 18 studies. The analysis of BMI and WC trends revealed that higher BMI and WC are observed with subjects that consume more red and processed meat.

Wagemakers et al. (2009) investigated the association of red or processed meat and the risk of Coronary Heart Disease (CHD) and determined that there was no evidence that the consumption of red or processed meat was a major risk factor for CHD but it contributes to increase WC. Cardiovascular disease and Type 2 diabetes, which are the same chronic disease associated with obesity, have been linked to meat consumption. Certain kind of cancers have also been linked to red meat or processed meat consumption. The WHO (2015) reported that '…each 50-gram portion of processed meat consumed daily increases the risk of colorectal cancer by

18%.’ Which was supported by the IARC, cancer agency for WHO, evaluation of the carcinogenicity of the consumption of red meat and processed meat. Researchers at the IARC (2015) used epidemiological analyses and determined that there was limited evidence that red meat consumption causes cancer but classified the consumption of red meat as probably carcinogenic to humans based on carcinogenic effect associated with colorectal cancer, pancreatic cancer and prostate cancer. Processed meat has been classified to be carcinogenic for humans based on sufficient evidence that consumption of processed meat causes colorectal cancer (Bouvard et al., 2015). The definition of processed meat used by Bouvard et al. (2015) and researchers at the IARC, is the same definition for processed meat as the one stated by WHO. The definition of processed meat used in this study and other studies is not always the same as the one defined by WHO, but nitrates, a cancer concern, are contained in most of the Statistics Canada categories of processed meat.

The purpose of this thesis is to estimate a meat demand system and assess the demand for processed meat in Canada and to measure the response of the quantity demanded for processed meat when faced with price changes. Consumer’s dietary patterns, tastes and preferences drive the market and influence marketing strategies (Ahmed & Mohamed, 2007) therefore understanding consumer preferences toward processed meat products will help provide information to decision makers that may facilitate a reduction in the consumption of unhealthy processed meat products in Canada and the accompanied impact on health outcomes.

The AIDS model is used for the empirical estimation of a meat demand system to obtain coefficients that can be converted into the elasticity of demand for processed meats in Canada, while accounting for income and substitution effects. Once the elasticity of demand is known we can examine how changes in price affect processed meat consumption.

1.3 Research Procedure

Consumer demand and substitution effects among fresh and processed meat products is assessed using the detailed food Survey of Household Spending for Canadian households and average meat expenditure data in each province for the period of 2010 to 2016. In this study, fresh meat refers to fresh or frozen beef, pork and poultry meat, with poultry including chicken and turkey. Processed meat refers to animal meat products that have undergone processing methods (such as cured hams, bacon and sausages). This study contributes to the literature by including processed meat in a meat demand system analysis. The demand system in this study assess the demand for different forms of meat products differentiated between fresh and processed. The price effect on substitution between the different meat products will be assessed with the estimated elasticities.

1.4 Thesis Outline

The second chapter of the thesis addresses the literature review on related studies and econometric models previously used for meat consumption studies. The third chapter addresses the data and methods, it includes a description of the panel data, the fixed and random effects model, the AIDS model, the LA/AIDS model and the elasticities. The fourth chapter presents the analysis and the results. The fifth chapter contains a conclusion of the thesis with the limitations and recommendations.

CHAPTER 2

ECONOMETRIC MODEL IN THE LITERATURE

2.1 Introduction

This chapter outlines the literature review regarding processed meat impacts and econometric models used to assess consumer demand for meat. Consumption analysis for meat products can be estimated with single equations or a system of equations. In this study, a single equation model is estimated in addition to the system of equations model based on the suggestion that regional differences could influence the model (Lambert et al., 2006). The estimation of a system of equations can be completed with two different approaches (Blanciforti, Green, & King, 1986). The first approach starts with utility functions that satisfy certain axioms of choice and the demand function is derived by maximizing the utility function subject to a budget constraint. The second approach starts with an arbitrary cost function and then restrictions are imposed on the system to obtain the demand functions. This study research applies the second approach, starting with a cost function the adding up, homogeneity and symmetry restrictions are imposed on the system. The linear and quadratic expenditure system, the Rotterdam Model, the Working Model, the Translog Model and the Almost Ideal Demand System (AIDS) are different algebraic specification of demand systems. The demand system approach chosen for this study is the Almost Ideal Demand System which is the most frequently used in previous literature on meat demand (Buse, 1994).

2.2 Meat Demand Studies in Canada

The Canadian demand for meat products has been estimated by various authors in the past but the research on consumer demand for meat in Canada is limited and dated. Previous studies on the consumption of meat in Canada include: Yeh, (1961); Kulshreshtha & Wilson (1972); Tryfos & Tryphonopoulos (1973); Salvanes, K.G., Devoretz (1997); and Lambert et al. (2006).

Yeh (1961) measured the reaction of Canadian consumer to changes in price of meat during the pre-war and post-war period. The aggregate-demand model in his paper is reduced to a single equation model which results are derived by the least-squares method. The price elasticity of demand for beef found was -0.535 and the price elasticity of demand for pork -0.343. The cross-price elasticities of beef and pork shows a significant degree of substitution between pork and beef consumption. Beef and pork were the only two meats included in his model, according to Yeh (1961) "beef and pork [were] the most important kinds of meat in Canada."

Kulshreshtha & Wilson (1972) used a two-stage least squares regression procedure to estimate the price elasticity of the Canadian beef cattle sector for the 1949 to 1969 period. The price elasticity of demand for beef found in the Canadian beef cattle sector was -0.801 which is higher than the one found in Yeh (1961) study as Kulshreshtha & Wilson (1972) estimated the price elasticity of demand only at the farm level.

Tryfos & Tryphonopoulos (1973) used a two-stage estimation procedure to analyze the demand for beef, veal, pork, lamb and chicken meat in Canada for the period 1950 to 1970. The price elasticity of beef obtained is -0.521 which is lower than the one obtained by Yeh (1961) and Kulshreshtha & Wilson (1972) but is still comparable for the same period. Another observation of Tryfos & Tryphonopoulos (1973) study was that beef, veal and domestic lamb consumption was not affected by changes in price of other meats but pork consumption was, suggesting asymmetric substitution effects between pork and beef.

Salvanes & DeVoretz (1997) used 1986 Canadian Food Expenditure Survey to investigate household demand for fish and meat products at different aggregation levels. Four LA/AIDS models were estimated to identify potential bias in price elasticities and identification of substitute. Testing for separability Salvanes & DeVoretz (1997) concluded that at the most aggregate level, fish and meat should be estimated together but at disaggregated levels it is acceptable to estimate fish and meat separately. Salvanes & DeVoretz (1997) also explained that the calculation of the own-price elasticity for different fish and meat products differs based on the subgroups included in the model.

Lambert et al. (2006) used data from the Canada's Food Expenditure Survey for 1992 and 1996 to investigate the demand for meat and fish across Canada. Lambert et al. (2006) used a two-step approach to a QUAIDS model to test whether there are regional differences in the demand elasticities for fish and meats and identified that regional differences including prices, age and ethnicity influence the demand elasticities for fish and meats.

2.3 Other Meat Demand Studies

Other studies on consumer meat demand have been done across the world. Some use single equation model such as the Working-Leser model (1963) to estimate the budget share of a food item (Chern, et al, 2003). In the Working-Leser model, each share of the food item is a linear function of the log of prices and the total expenditure on all the food items under consideration. However most recent research studies are using systems of demand equations such as the AIDS, QUAIDS, LA/AIDS and Translog to estimate the budget share of several food items since the models are compatible with household budget behaviour and allow for nonlinear Engel curves (Heien & Pompelli, 1988).

Heien & Pompelli (1988) completed a meat demand study for beef products using the AIDS model to obtain the price elasticities of demand for each beef product: steak, roast and ground beef which accounted for 95% of the beef products consumed according to the data from the USDA 1977 Household Food Consumption Survey (HFCS). Heien & Pompelli (1988) determined that demand for steak and ground beef was inelastic but demand for roast was price elastic and the cross-price elasticities between the beef products were significant making them substitutes.

Eales & Unnevehr (1987) completed a demand study for meat demand in the 1970s and 1980s using a dynamic AIDS model to compare meat demand for beef and chicken at aggregated and disaggregated level. They tested separability and structural change to determine if the consumer allocate meat expenditure by animal origin or by products. At the aggregated level, Eales & Unnevehr (1987) estimated the demand for chicken, beef and pork and at the disaggregated level demand for chicken products: whole birds and parts/processed and beef products: hamburger and table cuts. Eales & Unnevehr (1987) definition of processed meat is poultry sold in parts or beef sold as hamburger.

The literature on the meat demand is extensive, many meat demand studies suggest estimation of meat demand by estimating distinct meat product categories: disaggregated, to reflect own demand characteristics for each meat products. “Disaggregation allows a more precise analysis of the demand interrelationship between various types of meat” (Cashin, 1991). According to Brester (1996), aggregating products in single commodities can hide structural differences in demand for differentiated products. Other studies suggest investigating the response of meat demand by socio-demographic variables to explain how non-economic factors are important component in meat consumption patterns (Bansback, 1995; Huston, 1999). Newman, Henchion, and Matthews (2001) claim that career professional and younger consumers prefer processed meat over fresh meat due to convenience. In their study, the definition of processed meat includes bacon and ham. Yen and Lin (2008) state that highly educated consumers consume less meat and have lower expenditure on red meat. Yen, Lin, and Davis (2008) state that meat consumption decrease with age, households finding with elderly members consume less meat.

One of the topics not often mentioned in previous literature on the demand for meat is the budget share for processed meat. The demand for processed meat is often just included with the demand for the animal product it is derived from. The incentive for this study is to attempt to fill the void in the Canadian literature on processed meat consumption, using Statistics Canada data on the detailed food expenditure of Canadian provinces available in the Survey of Household Spending (SHS) for 2010 to 2016, the author assesses the budget-share of processed meat within the average Canadian household spending.

CHAPTER 3

DATA AND METHODS

3.1 Introduction

This section describes the data and model used for this study. The demand function for the quantity demanded for a commodity *i* can be expressed with respect to the price of the commodity *i*, prices of other commodities and the income. The demand function can be estimated by a single equation or within a system of equations. In this study, the demand function equations are estimated in a budget share form. Since the data used in this study are panel data, the single equation model applied to the data considers the random effects model, a technique to analyze panel data. The system of equations used for this study is the AIDS model, the most commonly used demand system model for meat studies.

Table 1

Name and description of meat products in Statistics Canada Survey of Household Spending

Name	Definition	Data
Beef (bf)	Fresh or frozen beef meat	Average household expenditure on beef
Pork (pk)	Fresh or frozen pork meat	Average household expenditure on pork
Poultry (pl)	Fresh or frozen chicken or turkey meat	Average household expenditure on chicken and turkey
Processed Meat (pc)	Bacon, uncooked ham, dinner ham, sausage (fresh or frozen, uncooked), wieners, deli and deli-style meat, other meat preparations such as canned meat or meat stew.	Average household expenditure on processed meat

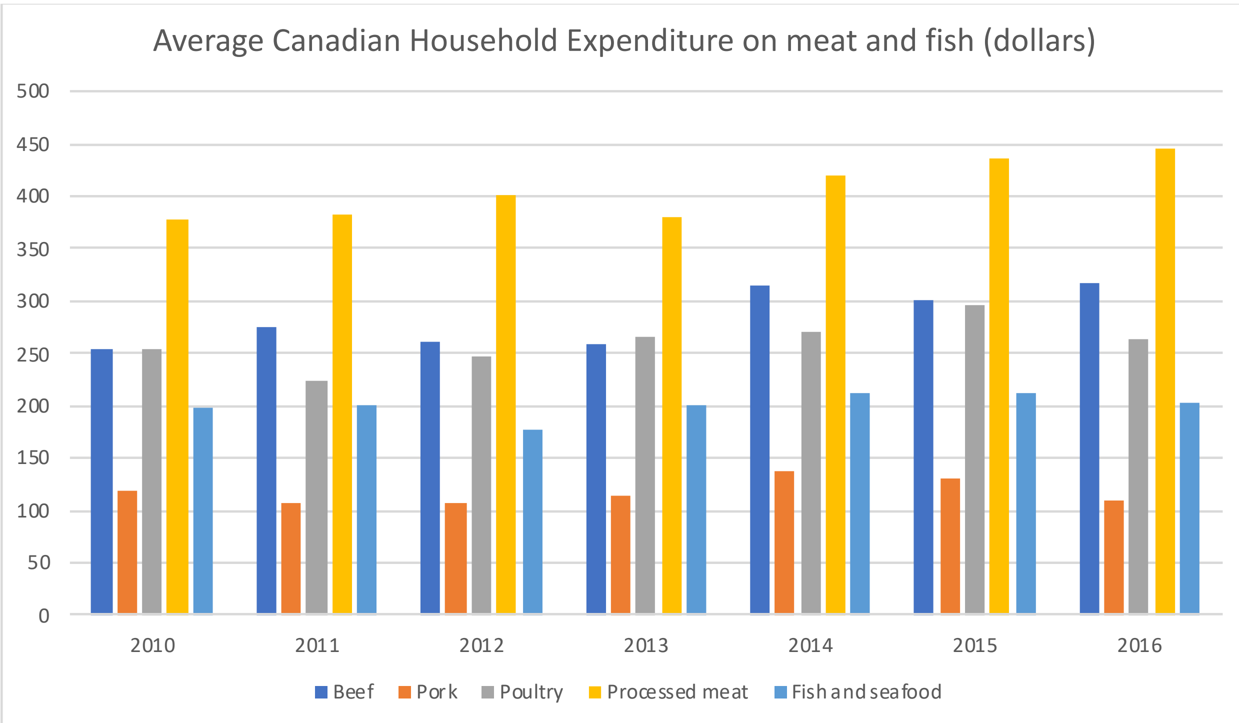
3.2 Data

Four different meat types are included in the analysis, namely beef, pork, poultry and processed meat. Descriptions of the variables are provided in Table 1, according to the definition used for the (SHS). The definition for processed meat used in the data is different from the one described in chapter 1. Ham and bacon, listed in the processed meat column in Table 1, are usually cured with the addition of nitrate but not all the processed meat included in Table 1 contain this chemical (Joseph, G., Sebranek, J., & Bacus, N. 2007).

The empirical analysis of this study relies on data collected in the SHS (Statistics Canada. CANSIM Table 203-0028). The SHS does not specify if the beef, pork and poultry categories include the fresh and frozen form of the meat, nor the type of cut. For example, there is no formal indication whether ground meat is included with the animal meat type or if it is considered processed as defined by the FAO. However, the processed meat category contains the major classifications of bacon, uncooked ham, dinner ham, sausage, wieners, deli and deli-style meat and other meat preparations such as canned meat or meat stew with no indication of frozen as a separate process. In this study, the author assumed that beef, pork and poultry include fresh and frozen forms of the animal meat and processed meat include the meat products listed in the SHS subcategories.

The SHS data from 2010 until 2016 are used to estimate the elasticities of the four meat types. The SHS is a cross-sectional survey conducted annually from households selected at random from target populations in the 10 Canadian provinces excluding people living in remote areas, members of the Canadian Forces and people living on reserves; which represent about 2% of the population of the 10 provinces. CANSIM Table 203-0028 includes detailed nominal food expenditure estimates for average households in the different Canadian provinces, regions and Canada. The estimates of average expenditure per household is calculated using the total of the weighted sum of expenditure data obtained by each of the survey instruments (Charlebois & Dubreuil, 2011).

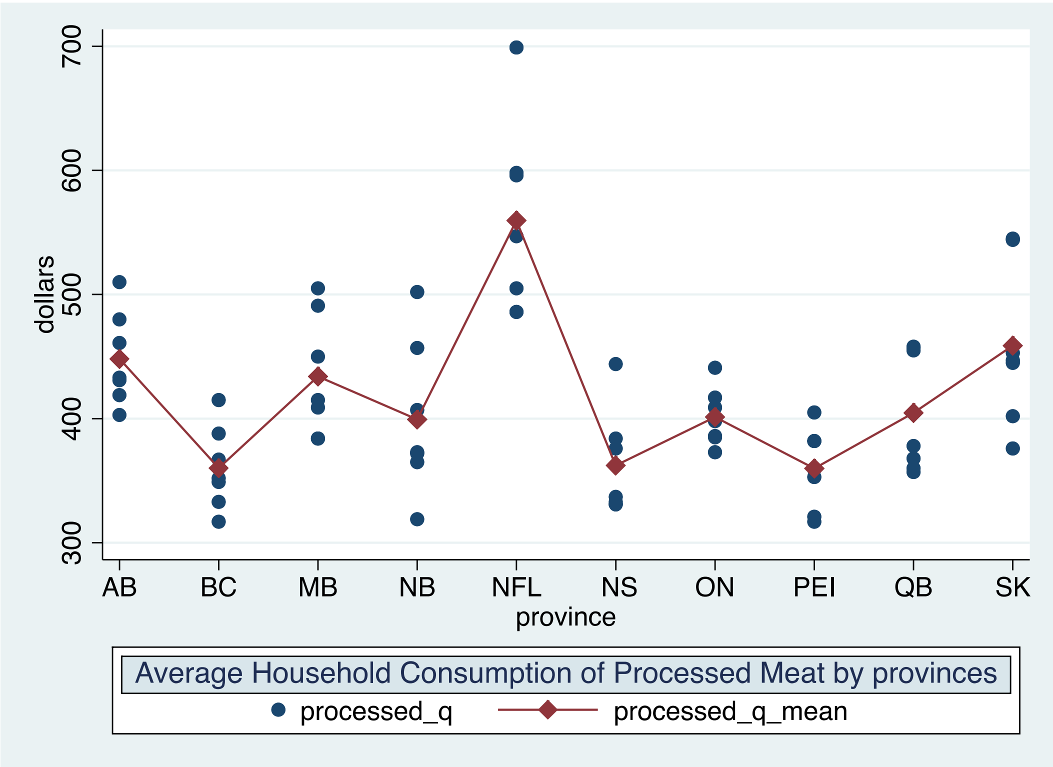
Figure 1: Average Canadian household expenditure on meat and fish



Source: Statistics Canada, Table 203-0028

The survey instruments consist of a questionnaire and two weekly diaries recording daily consumption details. The data collection is continuous throughout the year, from January to December and is completed on an average sample of 17,500 households (in 2010: 19,541 household; in 2011: 17,873 households; in 2012: 17,557 households; in 2013: 17,389 households; in 2014: 17,109 households; and in 2015: 17,603 households). The expenditure diaries and receipts of expenses from the households are collected by Statistics Canada and each expenditure is classified out of the 650 different codes available. Statistics Canada verifies and processes all expenditure diaries which are then converted to annual amounts. Figure 1 illustrates the average Canadian household expenditure in Canadian dollars for the different meat products and fish and seafood.

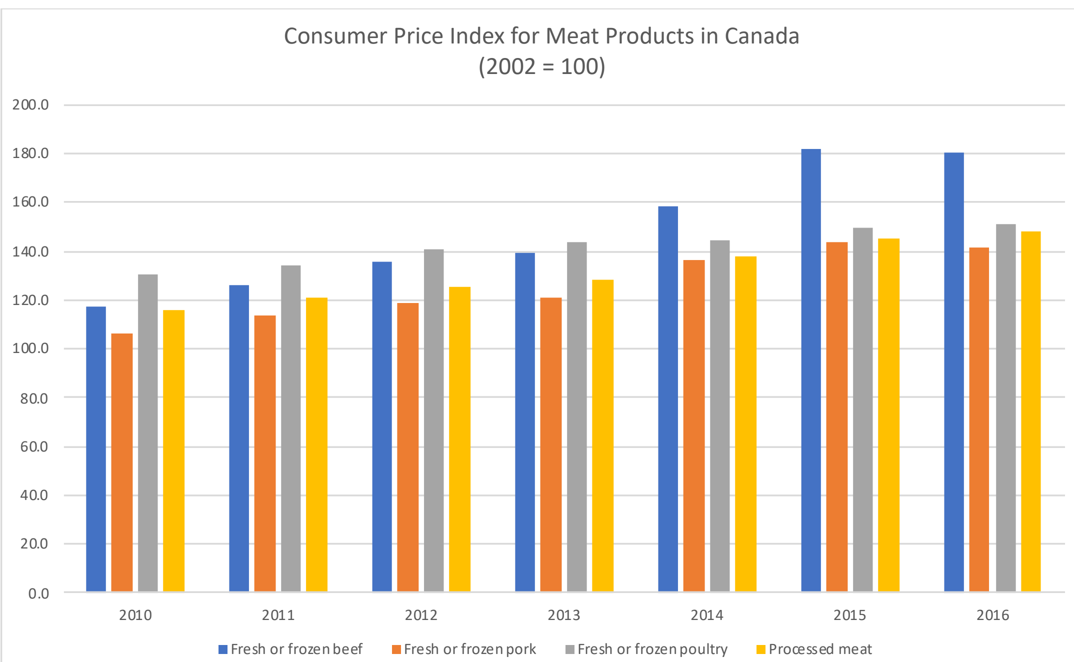
Figure 2: Heterogeneity across provinces for processed meat



To expand the number of observations available, the author used the panel data as there would not be enough observations to estimate the model as a time series or a cross section. Panel data sets use both time series and cross section data; including average provincial households' total food expenditures, total meat expenditures, beef expenditures, pork expenditures, poultry expenditures and processed meat expenditures for each Canadian province for every year between 2010 and 2016. This generates a total of 70 observations. Figure 2 illustrate the heterogeneity across provinces of the budget share for processed meat, each dot represents the observation for a year.

One advantage of using panel data is that it overcomes the problem of unobserved heterogeneity which occurs where there are unobserved variations in the characteristics of the respondents in a survey over time. Since space and time dimensions of the pooled data must be considered in the estimation procedure, the panel data are analyzed for fixed and random effects techniques. The Breusch-Pagan Lagrange multiplier (LM) test and the Hausman test are completed to test which technique should be used to analyze the data.

Figure 3: Consumer Price Index for Meat Products in Canada



The estimation of any demand system also requires information on prices. Consumer price index (CPI) data are used for the price variables in the models according to common practices (Blanciforti et al., 1986; Eales & Unnevehr, 1987). The CPI is a measure of the rate price change for good and services bought by Canadian consumers. It is obtained by comparing, through time, the cost of a fixed basket of commodities purchased in each year (Statistics Canada, 1996).

CPI groups associated with meat products are: fresh or frozen beef, fresh or frozen pork, fresh or frozen poultry and processed meat. The CPI groups will be used to match the prices of the different meat categories and the change between the same period are shown in figure 3. As we can see in figure 3, processed meat is a cheap alternative to fresh and frozen beef but between the years 2010 to 2013, fresh and frozen pork was the cheapest meat.

3.3 Single Equation Model

In the single equation model, each share of the food item is a linear function of the log of prices and the total expenditure on all the food items included in the model.

$$w_i = \alpha_0 + \alpha_{1i}\ln x + \sum_j \beta_{ij} \ln p_j + \varepsilon_i \qquad (1)$$

where (i,j) represent the four meat products, w_i is the expenditure share of the meat i among the four meat products, p_j is the price of the meat j, and x is the total expenditure of all the meat products included in the model.

Since the data sets used both time series and cross section, the decision between fixed or random effects model to analyze the panel data needs to be made as each province has its own individual characteristics that may or may not influence the variables included in the model. As explained in previous literature, Lambert et al. (2006), regional differences can influence the demand elasticity. The fixed effect model controls for all time-invariant differences between the provinces whereas the random effect model assumes that the variation across provinces is random and uncorrelated with the variables included in the model. The estimated coefficient for the fixed effects model and the random effect model are tested with the Hausman test to determine which model should be used to analyze the panel data. The LM test is used to test for random effects. The dependent variable is chosen to represent the budget share of beef, pork, poultry and processed meats. The meat demand equation is specified as follows for a fixed effects model:

$$w_i = \alpha_0 + \alpha_{1i}\ln(x) + \beta_{1i}\ln(P_{bf}) + \beta_{2i}\ln(P_{pk}) + \beta_{3i}\ln(P_{pl}) + \beta_{4i}\ln(P_{pc}) + \beta_{5i}(t) + \beta_{6i}(d_1)$$
$$+ \beta_{7i}(d_2) + \beta_{8i}(d_3) + \beta_{9i}(d_4) + \beta_{10i}(d_5) + \beta_{11i}(d_6) + \beta_{12i}(d_7) + \beta_{13i}(d_8)$$
$$+ \beta_{14i}(d_9) + \varepsilon \qquad (2)$$

The coefficients for the fixed effect equation are estimated with the OLS method since we assume that the parameters have equal variance and are uncorrelated to the error term.

Variables used in the econometric model:

Variable	Explanation
w_i	budget share for i (i= beef, pork, poultry, processed meat)
P_{bf}	consumer price index of beef meat
P_{pk}	consumer price index of pork meat
P_{pl}	consumer price index of poultry meat
P_{pc}	consumer price index of processed meat
I	total meat expenditure
t	trend
d_1	dummy variable for the province of Alberta.
d_2	dummy variable for the province of British-Columbia
d_3	dummy variable for the province of Manitoba
d_4	dummy variable for the province of New Brunswick
d_5	dummy variable for the province of Newfoundland and Labrador
d_6	dummy variable for the province of Nova Scotia
d_7	dummy variable for the province of Ontario
d_8	dummy variable for the province of Prince-Edward-Island
d_9	dummy variable for the province of Quebec
	no dummy variable for the province of Saskatchewan

the dummy variable takes the value of 1 if observed in the noted province and 0 otherwise

The meat demand equation may also be specified as follows for the random effects model:

$$w_i = \alpha_0 + \alpha_{1i}\ln(x) + \beta_{1i}\ln(P_{bf}) + \beta_{2i}\ln(P_{pk}) + \beta_{3i}\ln(P_{pl}) + \beta_{4i}\ln(P_{pc}) + \beta_{5i}(t) + \mu_i + \varepsilon_i \quad (3)$$

The random effects model is used in comparison to the fixed effects model if there is reason to believe that differences across provinces have some influence on the meats budget share. This will be tested with a Hausman test. The term μ accounts for the error between provinces while ε accounts for the error within data obtained for each province. The coefficients for the random effect equation are estimated with the GLS method as the error term is assumed to be correlated to the variables to a certain degree.

New variables used in the random effects econometric model:

Variable	Explanation
μ	error between provinces
ε	error within provinces

The difference between the OLS and GLS method used depend on the assumption made about the distribution of the error terms in the fixed effect and random effect equations. In the fixed effect equation, the error term is assumed to be equal across all values of the independent variables. This assumption is not made in the random effect equation.

3.4 Demand Elasticity for Single Equation Model

The expenditure elasticity formula from an expenditure equation as estimated above can be expressed as:

$$e_i = 1 + (\alpha_{1i}/w_i) \quad (4)$$

Taking the derivative of the single equation with respect to $\ln(p_j)$ we can obtain the uncompensated own and cross-price elasticities (e_{ij}):

$$e_{ij} = -\delta_{ij} + (\hat{\beta}_{ij}/\overline{w}_i) \quad (5)$$

where δ_{ij} is the Kronecker delta $\delta_{ij} = 1$ for i=j and $\delta_{ij} = 0$ otherwise. The average expenditure shares are represented by $\overline{w}_i$. $\hat{\beta}_{ij}$ is a parameter estimate.

3.5 System of Equations

While a single equation model can provide significant results for the demand for processed meat, the single equation model lack of symmetry hence the estimation of the AIDS model. The Almost Ideal Demand System (AIDS) is a flexible demand system developed by Deaton and Muelbauer (1980) to ease estimation of a demand system. The AIDS model implies that an increase in income will lead to a decrease in budget-share of a particular commodity. The homogeneity, symmetry and adding up restrictions can be imposed to the model with simple parametric restrictions (Moschini, 1998). Expenditure share (w_i) and price (p_i) variables for all meat categories are needed to estimate LA/AIDS model. The data on these variables for this study are available only from 2010 to 2016 (7 years of observations). CPI data are used for the price variables in the LA/AIDS models and quantities are represented by the average household expenditure (Blanciforti et al.,1986). The expenditure share (w_i) is obtained by dividing the expenditure of meat i by the sum of the product of the expenditure for each meat by their own price.

The AIDS model for the number of i food commodities can be estimated with the equation:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln (x/P) + \mu_i \qquad i = 1,\ldots,n \quad (6)$$

where w_i is the budget share (expenditure) of the i^{th} good, p_j is the CPI of the j^{th} good, x is the total expenditure within the system, μ_i is the random or error term and P is the translog price index defined by:

$$\ln P = \alpha_0 + \Sigma_j \alpha_j \ln p_j + \frac{1}{2} \Sigma_i \Sigma_j \gamma_{ij} \ln p_i \ln p_j \qquad (7)$$

The γ_{ij} parameters are defined under symmetry as:

$$\gamma_{ij} = \frac{1}{2} (\hat{\gamma}_{ij} + \hat{\gamma}_{ji}) = \gamma_{ji}$$

Where $\hat{\gamma}_{ij}$ is the estimated parameter for γ_{ij}. The price index makes the system non-linear which tends to complicate the estimation of the demand system therefore using a linear price index suggested by Deaton and Muelbauer (1980) should resolve the problem.

3.6 The LA/AIDS Model

The only difference between the AIDS and the LA/AIDS is in the specification of the price index. Several authors, including Buse (1994); Hahn (1994); Moschini (1995); Asche and Wessels (1997) have discussed the linear and nonlinear specifications and have agreed that the results of both are reasonably comparable.

As suggested by Deaton and Muelbauer (1980), The Stone's price index P* can be used to replace the translog price index (P*) and is defined by:

$$\ln P^* = \Sigma_i w_i \ln p_i \quad (8)$$

Substituting the Stone's price index for the translog price index in Equation (8) give the following expression for the LA/AIDS model:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(x/P^*) + \mu_i \quad (9)$$

Equation (9) can be applied to the empirical data to obtain the parameters required to calculate elasticities.

The adding-up, homogeneity and Slutsky symmetry restrictions are imposed on the model to make sure that the consumers' behavior in the demand system for the LA/AIDS model is consistent with consumer theory. The demand function needs to satisfy the budget constraint as such as the sum of the differentiation of the budget constraint with respect to income is equal to 1.

Adding up: $\Sigma_i\alpha_i = 1$

The demand function is homogeneous of degree 0, that is, when all the arguments of the functions are multiplied by any number greater than zero the value of the function remains the same. The demand function is homogeneous of degree zero in prices and income to ensure that the demand is not affected by a proportional increase in all prices and income.

Homogeneity: $\Sigma_i\gamma_{ij} = \Sigma_j\gamma_{ij} = 0$ and $\Sigma_i\beta_i = 0$

The symmetry condition is imposed on the LA/AIDS model to ensure that the estimated parameters of the demand functions satisfy the symmetric, negative semidefinite properties of the Slutsky matrix.

Slutsky Symmetry: $\gamma_{ij} = \gamma_{ji}$

3.7 LA/AIDS Price and Expenditure Elasticities

The expenditure elasticity η_i is obtain by taking the partial derivative of the LA/AIDS model equation with respect to ln(x).

$$\eta_i = 1 + (1/w_i)[\partial w_i/\partial \ln(x)]$$

Following Buse (1994) and Green and Alson (1991) the expenditure elasticity η_i can be written as:

$$\eta_i = 1 + \beta_i / w_i \qquad (10)$$

The Marshallian uncompensated elasticities are calculated for each meat product. The Marshallian uncompensated own (if j=i) and cross (if j≠i) price elasticities, $e^{LA/AIDS}{}_{ij}$ are obtained by taking the partial derivative with respect to ln (p_j) as follows:

$$e^{LA/AIDS}{}_{ij} = - \delta_{ij} + (1/w_i)[(\partial w_i/\partial \ln(p_j)]$$

$$e^{LA/AIDS}{}_{ij} = - \delta_{ij} + (\hat{\gamma}_{ij} /\overline{w}_i) - \hat{\beta}_i(\overline{w}_j/ \overline{w}_i)$$

$$e^{LA/AIDS}{}_{ij} = - \delta_{ij} + (\hat{\gamma}_{ij} - \hat{\beta}_i\overline{w}_j)/ \overline{w}_i \qquad (11)$$

where δ_{ij} is the Kronecker delta $\delta_{ij} = 1$ for i=j and $\delta_{ij} = 0$ otherwise; $\overline{w}_i$ represents the mean of the budget share; $\hat{\beta}_i$ and $\hat{\gamma}_{ij}$ are parameter estimates for the LA/AIDS model (9).

The LA/AIDS model can be estimated using the SAS 9.4 computer program with the iterative seemingly unrelated regression (ITSUR) estimation method (Goodwin, 2008). Once the LA/AIDS model is estimated, expenditure, own-price and cross-price elasticities can be calculated. The expenditure elasticities are important parameters in estimating future demand for different kinds of meat. Assessing the expenditure elasticities helps decision makers to forecast short, medium, and long run demand for meats, and make appropriate decisions (Chern, 2003).

The consumer demand behavior and the utility maximization principle are connected by the fundamental principle of the law of demand (Maki, 1992). The law of demand implies that the own-price elasticities of each meat products is expected to be negative (that own price has a negative impact in the demand function).

CHAPTER 4

RESULTS

For the single equation model, the Hausman test was completed to decide if the panel data estimation option used should be fixed or random effects. The Hausman Test evaluates the consistency of an estimator when compared to an alternative estimator assumed to be consistent (Hausman, 1978). It helps evaluate if a model corresponds to data. The null hypothesis for the Hausman test in panel data is that the errors are not correlated with the regressors, and therefore the random effects coefficients are consistent. The estimated Housman chi^2 with 5 degrees of freedom was 5.26 ($Prob>chi^2 = 0.3848$) therefore we fail to reject the null hypothesis at a significance level of 0.05 and conclude that the errors are not correlated with the regressors so the random effect should be used.

The Breusch-Pagan Lagrange Multiplier (LM) test was also completed to test for random effects. Similar to the Hausman test, the LM test helps decide between the random effects regression and a simple OLS regression. The null hypothesis in the LM test is that variances across provinces are zero; suggesting no fixed panel effects. The estimated LM $chibar^2$ with 1 degree of freedom was 12.28 ($Prob>chibar^2 =0.002$) therefore we can reject the null hypothesis and conclude that random effect is appropriate for this study.

Based on the result of the Hausman and Breusch-Pagan LM test, the panel data were estimated with the random effect model for the single equation and the cross-sectional variables were not included in the estimation of the demand system. The variation across the provinces were assumed to be random and uncorrelated with the budget share for processed meat and the prices for the different type of meats. The GLS parameters estimates and corresponding standard deviation for the random effect model are reported in Table 2.

Table 2

Parameter estimates of the random effect model

	budget share	α_1	$\ln P_{bf}$	$\ln P_{pk}$	$\ln P_{pl}$	$\ln P_{pc}$
beef	0.2847	0.0284	- 0.0652	0.1679**	-0.1257	- 0.0395*
pork	0.1037	0.0312**	-0.0110	0.0841**	-0.1655**	- 0.0350**
poultry	0.2431	-0.0164	-0.0336	-0.0964	0.1586	-0.0737**
processed meat	0.3685	-0.0330	-0.0699	-0.1171**	0.1800*	0.1592**

* Significant at the 10 percent level and ** Significant at the 5 percent level.

The theoretical coefficients are, for the most part, statistically significant at the 5% or 10% level except the coefficients for poultry and the coefficients with respect to the log of the price of beef which are not significant. The significance of the estimated coefficients is tested with a z-test. The z values greater than |1.96| are significant at a 5 percent level. The z values greater than |1.645| are significant at a 10 percent level. The * and ** in table 2 denotes the coefficients for the variables which have a significant influence on the budget share. The uncompensated elasticities and expenditure elasticities are calculated based on the coefficients obtained and are reported in table 3.

Table 3

Uncompensated and expenditure elasticities for the single equation model

	budget share	beef	pork	poultry	processed meat	expenditure elasticities
beef	0.2847	-0.771	0.5897*	-0.4415	-0.1387*	1.1000
pork	0.1037	-0.1061	-0.189*	-1.5959*	-0.3375*	1.3009*
poultry	0.2431	-0.1382	-0.3965	-0.3476	-0.3032*	0.9325
processed meat	0.3685	-0.1897	-0.3178*	0.4885*	-0.568*	0.9104

* Significant at 5 percent level.

The significant elasticities, based on the estimated parameters, are reported in table 3. The uncompensated own-price elasticities, recorded as diagonal elements highlighted in blue, carry negative signs in agreement to consumer theory. Based on the obtained random effect coefficients, we can determine that the demand is price inelastic for all meat products. The elasticity estimates indicate that the demand for pork is the least price elastic, meaning that change in price has a smaller effect on quantity consumed. The uncompensated own-price elasticities of beef (-0.7710) is comparable with some previous estimates for beef in Canada (Yeh (1961); Kulshreshtha & Wilson (1972)). The cross-price elasticities are recorded as non-diagonal elements in Table 3. Most of the estimated cross-price elasticities carry negative signs indicating the meat products are complements except beef and pork, and processed meat and poultry which have mixed cross-price elasticities signs, a concern that the single equation is not estimating a well behaving demand system.

As shown in Table 3, the expenditure elasticities are all positive suggesting that all the meat products are normal goods whose consumption will increase with increasing total expenditure on meat. The expenditure elasticities for processed meat and poultry are almost the same, with expenditure elasticity of processed meat being slightly lower than the one of poultry.

An empirical demand system can be estimated with the properties of a demand function restricted or tested. The LA/AIDS model with the Stone Price Index, in this study, is estimated with the imposed properties of aggregation (adding up), symmetric cross-price derivatives and homogeneity of degree zero in price and total expenditure. In order to comply with the adding-up property of demand functions, one of the four share equations, in this model the poultry equation was dropped for estimation purposes and the restrictions were imposed in the system. The symmetry restriction, restricts cross-price derivatives of the demand functions to be identical. The homogeneity restriction implies that the sum of the nominal price parameters in each share equation adds up to zero. The restricted LA/AIDS model is estimated by means of a ITSUR. The ITSUR parameters estimates and corresponding standard deviation for the LA/AIDS model are reported in Table 4.

Table 4

Parameter estimates of the LA/AIDS model

	budget share	intercept	β	beef	pork	processed meat	poultry
beef	0.2847	0.3091	- 0.0019	0.1776*	- 0.0014	- 0.0695*	- 0.1067
pork	0.1037	- 0.1309	0.0197		0.1011*	- 0.0417*	- 0.0580
processed meat	0.2431	0.4815	- 0.0094			0.0054	0.1713*
poultry	0.3685	0.3403	- 0.0084				0.0065

* significant at 5 percent level.

Note: The adjusted R^2 for beef equation is 0.3789. The adjusted R^2 for pork equation is 0.3286. The adjusted R^2 for processed meat equation is 0.616. The system weighted R^2 = 0.4975.

The values for the adjusted R^2 of the respective equation and the system are low. The estimate for the corresponding parameters for the poultry meat were calculated from the restriction applied to the LA/AIDS model. The significance of the regression coefficient is tested with a t-test with zero mean and 69 degrees of freedom since the dataset contains 70 observations. The *t* distribution with 69 degrees of freedom may be approximated by the *t* distribution with 60 degrees of freedom where t value superior or equal to 2.000 is significant at a 5 percent level. The * denotes in table 4 the coefficients statistically significant.

Although some of the parameter estimates are not significant, the elasticities are calculated and reported in Table 5. Uncompensated Marshallian own and cross-price elasticities were calculated at their sample means by using equation (11) using the parameters estimates obtained in Table 4 and are presented in Table 5. Table 5 also presents expenditure elasticities and marginal expenditure elasticities for the restricted model.

Table 5

Uncompensated elasticities and expenditure elasticities

Meat	budget share	beef	pork	poultry	processed meat	expenditure elasticities
beef	0.2847	-0.37434 * (-2.49)	-0.00422	-0.37232	-0.24249	0.99332
pork	0.1037	-0.06758	-0.04356 (-0.19)	-0.62931	-0.4483	1.18997
poultry	0.3685	-0.28306	-0.15503	-0.55651* (-2.45)	0.29265	0.9772
processed meat	0.2431	-0.27488	-0.16752	0.71889	-0.97597* (-5.87)	0.96133

*Significant at the 5 percent level. t-value in parenthesis for own-price elasticity

The uncompensated own-price elasticities, recorded as diagonal elements highlighted in blue, carry negative signs in agreement to consumer theory. They differ, however, in magnitude from the own-price elasticities obtained in the random effect equation model. The demand for all meat products is also price inelastic like in the random effect equation model despite the own-price elasticity of processed meat (-0.97597) being close to unity. The demand for pork is the least price elastic in this model too. The uncompensated own-price elasticities of beef (-0.37434) is still comparable with some previous estimates for meat in Canada (Yeh (1961); Kulshreshtha & Wilson (1972)).

The cross-price elasticities are recorded as non-diagonal elements in Table 5. The cross-price elasticities for processed meat demand and poultry price and vice versa carry positive signs indicating the products are substitutes. The consumption of poultry shows the strongest substitute response for the price of processed meat (0.7189) whereas the consumption of processed meat isn't as responsive to the price of poultry (0.2927). All other cross-price elasticities are negative indicating that the other products are complements. The consumption of beef isn't responsive to the price of pork (-0.0676) and similarly the demand for pork isn't responsive to the price of beef (-0.0042). The consumption of processed meat is responsive to the price of beef (-0.2425) and pork (-0.4483). Given that most of the processed meats are produced from beef or pork or byproducts, an increase or decrease in the prices of beef and/or pork could reflect on the consumption of processed meat. Higher prices for beef or pork lead to a fall in demand for processed meat.

As shown in Table 5, the expenditure elasticities are all positive suggesting as well that all the meat products are normal goods whose consumption will increase with increasing total expenditures although these are not significant in the estimation.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 Conclusion

This study reports the research results from modelling Canadian household meat consumption behaviour by using household-level data for the period of 2010 to 2016. The SHS provides the data for estimating food demand in Canada. This study estimates the Canadian demand for beef, pork, poultry and processed meat products. The own-price, cross-price and expenditure elasticities of the four meat products were estimated.

Although the regression coefficients of concern obtained through the single equation are mostly significant, since no restriction were imposed on the model the obtained results are inconsistent with consumer theory. The regression coefficients obtained in the AIDS demand system are for the most part not significant at the 5% level but consistent with basic economic theory therefore the resulting elasticities estimates are satisfactory. Beef, pork, poultry and processed meat are normal goods, and inelastic to price.

The elasticity parameters in both models were significant for processed meat so we can argue that the study's point estimates of the own-price elasticity of processed meat are accurate for the data and models. The point estimates from -0.9760 to -0.5680, depending on the restrictions imposed. The own-price elasticity for processed meat does confirm that the demand for processed meat is the most elastic out of all the meat products in the restricted model and second most elastic after beef in the unrestricted estimation. Therefore, a tax on processed meat could have considerable effects on consumption and could reduce the negative health outcomes of high consumption of processed meat.

The cross-price elasticities obtained in both models were negative between beef, pork, and processed meat suggesting that the three meat products were complements. This does not conform to expectations that meat products are substitutes. Only the cross-price elasticity between processed meat and poultry suggest that those two meat products could be substitutes.

5.2 Limitations and Future Work

The goal of this study was to estimate the elasticity of demand for processed meat for potential policies implication to reduce the consumption of processed meat and its possible negative health outcomes. Meat demand studies in Canada are limited and dated therefore it is reasonable to question whether the elasticity estimates for processed meat obtained in this study can be trusted to provide accurate information to decision makers. This section provides the limitations of this study to gives recommendations for future work.

First, more observations should be included in future work. This study estimated the elasticity of demand for processed meat between the year 2010 and 2016 for each Canadian province giving a total of 70 observations. A lack of variations in the price, consumption and income during that period could have been overlooked.

Second, the meat products included in the model should be tested for weak separability to understand how consumers allocate their meat expenditures and whether fish or other protein sources are part of that decision. The estimated elasticities for processed meat was based on the meat products included in the model and the data definition of processed meat. This study uses provincial aggregate data calculated by Statistics Canada which softens variation in the data but also does not specify an explicit aggregation level for the meat products. More accurate elasticities could be obtained with different levels of aggregation of the meat products included in the model.

Third, demographic effects were tested with the Hausman and LM tests and shown to be random and uncorrelated with the budget share for processed meat and the prices for the different types of meats therefore demographic effects were not included in the models. Nonetheless, other socio-demographic factors such as age, sex, level of education, employment status, income, religion and other factors could affect the consumption of processed meat.

Fourth, the type of tax to apply on processed meat to reduce health risk should be selected cautiously. Hart, A., 1936 warned that a tax has its own direct impact on consumer awareness more than just a price. Thus, the application of a tax on processed meat might be more effective than the estimated price effect if it was preceded by an awareness campaign on the negative health outcomes of consuming high amount of processed meat or a revision to the Canadian Food Guide to remove chemically modified meat alternatives as suggestion for a healthy diet. Education on other cooking methods to save time in food preparation could also reduce consumption of processed meat.

REFERENCES

Ahmed, A. F., & Mohamed, Z. (2007). Consumer's perfection of mutton consumption in Peninsula Malaysia. Journal of ISSAAS [International Society for Southeast Asian Agricultural Sciences] (Philippines).

Alston, J. & Chalfant, J. (1993) The silence of the lambdas: a test of the almost ideal and Rotterdam models. American Journal of Agricultural Economics 75:300-13.

Asche, F. & Wessels, C.R. (1997). On price indices in the Almost Ideal Demand System. American Journal of Agricultural Economics 79:1182–1185.

Atkins, R.C. (2004). Atkins for Life: The Complete Controlled Carb Program for Permanent Weight Loss and Good Health. New York, NY: St Martins Press, 2004.

Awudu, A., Jain, D.K., & Sharma, A.K. (1999). Households food demand analysis in India. Journal of Agricultural Economics, 50(2), 316-327.

Bansback, B. (1995). Towards a broader understanding of meat demand - Presidential Address. Journal of Agricultural Economics, 46(3), 287-308.

Barnes, R., & Gillingham, R. (1984). Demographic Effects in Demand Analysis: Estimation of the Quadratic Expenditure System Using Microdata. The Review of Economics and Statistics, 66, 591-601.

Berdanier, C., Gorny, J. R., Yousef, A. E. (2000). Advanced Nutrition: Macronutrients, 2nd ed. Boca Raton, FL: CRC Press.

Bewley, R. (1987). The demand for milk in Australia: Estimation of price and income effects from the 1984 Household Expenditure Survey Australian Journal of Agricultural Economics 31(. 3):204 – 218

Blanciforti, L.A., Green, R.D., & King, G.A. (1986). U.S. Consumer Behavior over the Postwar Period: An Almost Ideal Demand System Analysis. Giannini Foundation Monograph Number 40 • August 1986

Bouvard, V., Loomis, D., Guyton, K.Z., Grosse, Y., El Ghissassi, F., Benbrahim-Tallaa, L., et al. (2015). Carcinogenicity of consumption of red and processed meat The Lancet Oncology. Published online 26 October 2015. http://dx.doi.org/10.1016/S1470-2045(15)00444-1

Brester, G.W. (1996). “Estimation of the U.S. Import Demand Elasticity for Beef: The Importance of Disaggregation.” Review of Agricultural Economics, 18(1): 31-42.

Burton, M., Dorsett, R., & Young, T. (1996). Changing preferences for meat: Evidence from the UK household data 1973-93. European Review of Agricultural Economics, 2, 3.

Buse, A. (1994). Evaluating the linearized Almost Ideal Demand System. American Journal of Agricultural Economics 74:781-793

Cashin, P. (1991). “A Model of the Disaggregated Demand for Meat in Australia.” Australian Journal of Agricultural Economics, 35(3): 263-283.

Charlebois, J. & Dubreuil, G. (2011). Variance Estimation for the Redesigned Survey of Household Spending. Proceedings of the Survey Methods Section, Statistical Society of Canada Annual Meeting, June 2011

Chern, W.S.; K. Ishibashi; K. Taniguchi and Y. Yokoyama. 2003. "Analysis of Food Consumption Behavior by Japanese Households." Economic and Social Development Paper No. 152. Food and Agriculture Organization. Rome

Deaton, A., & Muelbauer, J. (1980). An Almost Ideal Demand System. The American Economic Review 70(3):312-326

Eales, J.S., & Unnevehr, L.J. (1987). Demand for Beef and Chicken Products: Separability and Structural Change. Proceedings of the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. Chicago, IL.

Eales, J.S., & Unnevehr, L.J. (1994). The inverse almost ideal demand system, European Economic Review. Volume 38, Issue 1, Pages 101-115. ISSN 0014-2921, http://dx.doi.org/10.1016/0014-2921(94)90008-6.

Gardner, C.D., Kiazand, A., Alhassan, S., Kim, S., Stafford RS, Balise, R.R. et al. (2007). Comparison of the Atkins, Zone, Ornish, and LEARN diets for change in weight and related risk factors among overweight premenopausal women: The A to Z Weight Loss Study: a randomized trial. JAMA 2007; 297: 969–977.

Goodwin, B. (2008). SAS/ETS examples: Estimating an Almost Ideal Demand System model. Available at http://support.sas.com/rnd/app/examples/ets/aids/.

Goodwin, B. (2008). SAS/ETS examples: Calculating elasticities in an Almost Ideal Demand System model. Available at http://support.sas.com/rnd/app/examples/ets/elasticity/.

Government of Canada (2010). Consumer Trend Report – Convenience. Retrieved from Agriculture and Agri-Food Canada Website: https://www.gov.mb.ca/agriculture/market-prices-and-statistics/trade-statistics/pubs/canada_convenience_trend_report_en.pdf

Haden, K. (1990). The demand for cigarettes in Japan, American Journal of Agricultural Economics, 72:446-50

Hahn, W. (1994). Elasticities in AIDS Models: Comment. American Journal of Agricultural Economics, 76(4), 972-977. Retrieved from http://www.jstor.org/stable/1243761

Hart, A. (1936). Consumption taxation as an instrument of economic control. Law and Contemporary Problems.

Hausman, J.A. (1978). Specification Tests in Econometrics. Econometrica, 46 (6), 1251-1271.

Heckman, J.J. (1979). Sample selection bias as a specification error. Econometrica, 47, 153-161.

Heien, D., & Pompelli, G. (1988). The Demand for Beef Products: Cross Section Estimation of Demographic and Economic Effects Western Journal of Agricultural Economics 13(1) 37 – 44

Heien, D., & Wessells, C.R. (1990). Demand systems estimation with microdata: A censored regression approach Journal of Business and Economic Statistics, 365–371

Heinz, G., & Hautzinger, P. (2007). Meat processing technology for small to medium scale producers. RAP Publication (FAO), no. 2007/20. FAO, Bangkok, Thailand: Regional Office for Asia and the Pacific.

Huston, J. L. (1999). Beef marketing challenges in the US. IMS newsletter, (207).

Joseph, G., Sebranek, J., & Bacus, N. (2007) Cured meat products without direct addition of nitrate or nitrite: what are the issues?, Meat Science, Volume 77, Issue 1, 2007, Pages 136-147, ISSN 0309-1740, https://doi.org/10.1016/j.meatsci.2007.03.025.

Kulshreshtha, S.N., & Wilson, A.G. (1972). An Open Econometric Model of the Canadian Beef Cattle Sector. American Journal of Agricultural Economics, 54: 84-91.

Lambert, R., Larue, B., Yélou, C. & Criner, G. (2006). Fish and meat demand in Canada: Regional differences and weak separability. Agribusiness, 22: 175–199. doi:10.1002/agr.20079

Lazaridis, P. (2003). Household Meat Demand in Greece: A Demand Systems Approach Using Microdata. Agribusiness, Vol. 19 (1) 43–59

Leitzmann, C. (2005). Vegetarian diets: what are the advantages? Forum. Nutr 2005; 147–156.

Maki, A. (1992) Structural Change and Economic Dynamics. Volume 3, Issue 1, June 1992, Pages 167-176

Moschini, G. (1995). Units of measurement and the Stone index in demand system estimation. American Journal of Agricultural Economics, 77, 63– 68

Moschini, G. (1998). The semiflexible almost ideal demand system. European Economics Review, 42: 346-364

Newman, C., Henchion, M., & Matthews, A. (2001). Infrequency of purchase and double - hurdle models of Irish households' meat expenditure. European Review of Agricultural Economics, 28(4), 393-419.

Nicklas, T.A., Farris, R.P., Myers, L. & Berenson, G.S. (1995). Impact of meat consumption on nutritional quality and cardiovascular risk factors in young adults: the Bogalusa Heart Study. J Am Diet Assoc 1995; 95:887-892.

Pitt, M. M. (1983). Food Preferences and Nutrition in Rural Bangladesh. The Review of Economics and Statistics, 65, 105-1

Pollak, R.A., & Wales, T.J. (1981). Demographic Variables in Demand Analysis. Econometrica 49(6):1533–51.

Powell, A. A. (1974) “Empirical Analysis of Demand Systems”, D.C. Health Company.

Rouhani, M.H., Salehi-Abargouei, A., Surkan, P.J. & Azadbakht, L. (2014) Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. Obes Rev, 15: 740-748. Doi:10.1111/obr.12172

Sabate, J. (2003). The contribution of vegetarian diets to human health. Forum Nutr 2003; 56: 218–220.

Salvanes, K., & DeVoretz, D. (1997). Household Demand for Fish and Meat Products: Separability and Demographic Effects. Marine Resource Economics, 12(1), 37-55. Retrieved from http://www.jstor.org/stable/42629181

Savadogo, K., & Brandt, J A. (1988). Household Food Demand in Burkina Faso: Implications for Food Policy. Agricultural Economics 2:345 – 364

Schulze, M.B., Manson, J.E., Willett, W.C., & Hu, F.B. (2003). Processed meat intake and incidence of Type 2 diabetes in younger and middle-aged women. Diabetologia 2003; 46: 1465–1473 https://doi.org/10.1007/s00125-003-1220-7

Shay, C.M., Van Horrn, L., Stamler, J., et al. (2012) Food and Nutrient intake and their associations with lower BMI in middle-age US adults: The International Study of Macro- /Micronutrients and Blood Pressures (INTERMAP). American Journal of Clinical Nutrition 2012; 96/; 483-491.

Statistics Canada. (1996). Your Guide to the Consumer Price Index. Catalogue No 62-557-XPB.

Statistics Canada. Table 203-0028 (2017) - Survey of household spending (SHS), detailed food expenditures, Canada, regions and provinces, annual (dollars), CANSIM (database). (last accessed March 2018)

Statistics Canada. Table 326-0021 (2018) - Consumer price index, annual (2002=100 unless otherwise noted), CANSIM (database). (last accessed March 2018)

Togo, P., Osler, M., Sorensen, T.I. & Heitmann, B.L. (2001) Food intake patterns and body mass index in observational studies. Int J Obes Relat Metab Disord 2001; 25: 1741–1751

Tryfos, P., & Tryphonopoulos, N. (1973). Consumer Demand for Meat in Canada. American Journal of Agricultural Economics, 55(4), 647-652.

Wagemakers, J. J. M. F., Prynne, C. J., Stephen, A. M., & Wadsworth, M. E. J. (2009). Consumption of red or processed meat does not predict risk factors for coronary heart disease; results from a cohort of British adults in 1989 and 1999. European Journal of Clinical Nutrition, 63(3), 303-11. Doi: http://dx.doi.org.uml.idm.oclc.org/10.1038/sj.ejcn.1602954

Wang, Y. & Beydoun, M.A. (2009) Meat consumption is associated with obesity and central obesity among US adults. Int J Obes (Lond). 2009 Jun; 33(6): 621-8. Doi: 10.1038/ijo.2009.45. Epub 2009 Mar 24.

World Health Organisation, International Agency for Research on Cancer. (2015). Press release No 240. ARC Monographs evaluate consumption of red meat and processed meat. Available at: http://www.iarc.fr/en/media-centre/pr/2015/pdfs/pr240_E.pdf (accessed Nov 2, 2015)

Wyness, L., Weichselbaum, E., O'Connor, A., Williams, E.B., Benelam, B., Riley, H. & Stanner, S. (2011). Red meat in the diet: An update. Nutrition Bulletin 36(1): 34-77.

Yeh, M.H. (1961). Consumer Demand for Beef and Pork in Canada. Canadian Journal of Agricultural Economics, 9:68-78.

Yen, S. T., & Lin, B. H. (2008). Quasi-maximum likelihood estimation of a censored equation system with a copula approach: meat consumption by US individuals. Agricultural Economics, 39(2), 207-217.

Yen, S.T., Lin, B.H., & Davis, C.G. (2008). Consumer knowledge and meat consumption at home and away from home. Food Policy, 33(6), 631-639.