THE ECONOMICS OF HEALTH FOODS AND POLICY ISSUES: IMPACT OF HEALTH CLAIMS ON DEMAND AND POPULATION HEALTH

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ABSTRACT

Chronic disease accounts for 70% of deaths globally and causes substantial economic burdens. The largest direct healthcare costs associated with illness in Canada is due to cardiovascular disease (6.8% of total costs) followed by cancer (2.2%) and diabetes (1.3%). Research has indicated diet can significantly reduce the risk of many chronic diseases. Governments use health claims to inform consumers about foods' health attributes and encourage healthy diets. This thesis examines the impacts of health claim policy on food demand and population health in North America. The demand for food is estimated using a linear-approximate almost ideal demand system. Population health is evaluated using a health production function. The results indicate health claims decreased unhealthy food demand between 1.4% and 6.26% and increased healthy food demand between 1.95% and 8.47%. Diet and health claim policy also positively impact population health. Policy recommendations to improve current health claim policy are provided.

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LIST OF ABBREVIATIONS

AAFC	Agriculture and Agri-Food Canada
AIDS	Almost Ideal Demand System
BP	Breusch-Pagan
CDC	Centers for Disease Control and Prevention
CFIA	Canadian Food Inspection Agency
CHD	Coronary Heart Diseases
CLA	Conjugated Linoleic Acid
CVD	Cardiovascular Disease
DSHEA	Dietary Supplement Health and Education Act
EC	European Commission
E.U.	European Union
EUFIC	European Food Information Council
EFSA	European Food Safety Authority
FDA	Food and Drug Administration
FDAMA	Food and Drug Administration Modernization Act
FGLS	Feasible Generalized Least Squares
FOP	Front-of-Package
GM	Genetically Modified
IAIDS	Inverse Almost Ideal Demand System
IFIC	International Food Information Council
ITSUR	Iterative Seemingly Unrelated Regressions
LA/AIDS	Linear Approximate Almost Ideal Demand System
MPB	Marginal Private Benefit
MSB	Marginal Social Benefit
MSC	Marginal Social Cost
NCD	Non-Communicable Diseases
NFT	Nutrition Facts Table
NHP	Natural Health Products
NLEA	Nutrition Labeling and Education Act
OECD	Organization for Economic Development and Cooperation
QUAIDS	Quadratic Almost Ideal Demand System
SSA	Significant Scientific Agreement
SUR	Seemingly Unrelated Regressions
U.S.	United States
WHO	World Health Organization
WTP	Willingness-to-Pay

CHAPTER 1

1. Introduction

Chronic illness is a global epidemic that has placed substantial economic and social burdens on societies around the world (WHO 2017a). In 2015, 70% of deaths globally were attributed to chronic disease (WHO 2017a). The top four causes of chronic disease deaths were due to cardiovascular diseases (CVDs), cancers, diabetes, and chronic respiratory illnesses. CVDs accounted for the largest portion of these causing 45% of chronic disease mortalities followed by cancer, which accounted for 22% of all chronic disease deaths in 2015 (WHO 2017a). It is now recognized that CVDs, cancer, obesity and diabetes "are among the most common, costly, and preventable of all health problems" (CDC 2017a, website). The direct economic costs of chronic illness include wages to healthcare workers, hospital costs, and pharmaceutical expenditures (Public Health Agency of Canada 2014). In addition, there are significant indirect and social costs associated with chronic illness, such as reduced labour market productivity, opportunity costs, a decreased quality of life, and physical and emotional pain caused by illness.

Research has found that many chronic diseases, such as CVD, some types of cancer, obesity and diabetes, can be prevented or the risk can be significantly reduced through the adoption of a healthy lifestyle (Dietz, Douglas and Brownson 2016). Organizations such as the World Health Organization (WHO), the American Heart Association, and the Centers for Disease Control and Prevention (CDC) now recommend adopting a healthy diet as part of a preventative care strategy (WHO 2003; American Heart Association 2017a; CDC 2017a).

Increased knowledge about the link between diet and health and a desire to improve well-being has fostered a growing interest from consumers in the adoption of a healthy diet

(Milner 1999; Moors 2012; Hobbs et al. 2014). In addition, policymakers have taken a keen interest in promoting preventative care strategies, such as healthy diets, to reduce the economic burdens of chronic illness (Veeman 2002; Aschemann-Witzel 2011).

This increased interest in the use of diet as a means for improving health has been a driver for growth in the functional foods and natural health products (NHPs) industry (Milner 1999; Moors 2012; Hobbs et al. 2014). Functional foods are foods that have health benefits beyond basic nutrition whereas NHPs are supplements made from isolated food or food constituents, sold in dosage form and taken for certain health benefits (Veeman 2002; AAFC 2014; Hobbs et al. 2014).

During the 1980s, public health authorities in Japan first recognized that certain foods provided extra health benefits and began regulating these products under independent regulations that were different than conventional foods (Ohama, Ikeda, and Moriyama 2006; Hobbs et al. 2014). Since then, countries around the world have adopted their own unique set of regulations and definitions for functional foods and NHPs. Current market estimates of the size of the functional food and health product industry cover a broad range due to a lack of consensus regarding the definitions of functional foods and natural health products (Stein and Rodriguez-Cerezo 2008). The Nutrition Business Journal estimates "the largest market worldwide is Japan (EUR 21.8 billion in 2001), followed by the USA (EUR 20.7 billion) and Europe (EUR 20.1 billion)" (Stein and Rodriguez-Cerezo 2008, 21).

To inform consumers about the health benefits associated with the consumption of functional foods and NHPs and promote the adoption of a healthy diet, governments use health claim policy. Health claims are statements that indicate a relationship between the consumption of a food and a health benefit (CFIA 2016c). Due to the 'credence' nature of functional foods, consumers are unable to easily verify the truthfulness of health claims on product labels (Veeman 2002; Henson, Herath and Cranfield 2006). Credence characteristics are those that cannot be confirmed either before or after the consumption of a good. With functional foods, many of the health benefits are not immediate and occur only after prolonged use. The use of health claims has created a solution to the issue of conveying the credence attributes of functional foods to consumers.

However, unregulated health claims could lead to significant problems. First, since the average consumer is unable to discern easily the accuracy of the information provided easily, producers have an incentive to use false or misleading information to market their products (Veeman 2002; Henson, Herath and Cranfield 2006). Second, if the information is not easy for the average consumer to understand, they might not know how to appropriately use the health information provided in claims leading to increased confusion and uncertainty in the marketplace (Mariotti et al. 2010).

Today, public health authorities in Canada and the U.S. regulate health claims to improve dietary patterns through the provision of accurate, credible and easy to understand health information. If successful, health claims can increase the consumption of healthier foods and lead to a reduced incidence of chronic disease and the associated economic and social burdens placed on society. However, the efficacy of current health claim regulations on improving the demand for healthier foods has not been adequately addressed in the literature. Previous research has focused on the "ex-ante" factors that contribute to consumer acceptance and willingness-to-pay (WTP) for functional foods and health products (e.g., Verbeke 2005; Teratanavat and Hooker 2006; Herath, Cranfield, and Henson 2008; Markosyan, McCluskey, and Wahl 2009). The literature also has examined the "ex-ante" impacts of health claims on product evaluations and purchase intentions (e.g., van Kleef, van Trijp, and Luning 2005; van Trijp and van der Lans 2007; Huang and Lu 2016). Further, the literature has provided considerable insights into factors that contribute to population health status (e.g., Shaw, Horrace and Vogel 2005; Fayissa and Gutema 2005; Joumard et al. 2008; Cremieux, Ouellette, and Pilon 1999; Miller and Frech 2000). However, the literature has not examined the "ex-post" impacts of current health claim regulations in North America on the demand for healthy foods or the impacts of health claim regulations on population health status in North America.

1.1 Thesis Objective

The primary objective of this thesis is to evaluate the impacts of health claim regulations in Canada and the United States on the demand for relevant foods in each country. By evaluating the efficacy of health claim regulations at influencing consumption patterns, the goal of this thesis is to provide an understanding of which health claims are effective at influencing consumption patterns and determine government policies that could improve the efficiency of the current systems in Canada and the U.S. The second objective of this study is to examine how population health status of North Americans has changed over time and whether the introduction of health claim policies has impacted health outcomes in Canada and the U.S.

1.2 Thesis Contribution

The impacts of health claim regulations on consumer demand for functional foods and population health status in Canada, the U.S., and abroad have not been addressed in the literature. This thesis contributes to the literature by providing an understanding of the efficacy of current health claim regulations at changing the demand for functional foods in Canada and the U.S. In addition, it investigates the impacts of health claim regulations at improving health outcomes in North America as well as changes in population health status over time. Further, it provides policy recommendations that can improve the success and efficiency of the current health claim legislation in North America at influencing consumption patterns towards healthier foods. Improvements in the current regulatory framework can increase the well-being of the public through a direct improvement in the health status as well as a reduction in the related healthcare expenditures.

Further, the insights provided by this thesis can also serve as a guide to firms in the functional food industry. By understanding which claims are effective at influencing demand, firms can use this information for future product development, market access and pricing. In addition, a more efficient system will encourage continued growth in the Canadian functional food industry by attracting further domestic and foreign investment. Lastly, it evaluates how dietary factors have changed over time and influenced health status in North America.

1.3 Thesis Outline

The rest of this thesis is organized as follows. Chapter 2 by provides an overview of the definitions and regulations governing health foods in Canada and the U.S. and how they compare to the regulatory framework in the E.U. As the regulations for functional foods and natural health products overlap, a brief discussion of natural health products is provided. However, this review focuses mostly on functional foods and their health claims as they are the main issue being examined by this thesis. Chapter 2 also includes an overview of the incidence and burden of chronic illness and a discussion of the size of the functional foods and natural health products market.

Next, Chapter 3 provides a review of the relevant literature on the issues related to functional foods, health claims, the demand for foods and population health. Chapter 4 discusses the theoretical model, econometric specification and data used to estimate the demand for the functional foods and population health status in Canada and the U.S. The Linear Approximate Almost Ideal Demand System (LA/AIDS) model is used to estimate the demand for foods and a log-linear health production function is used to estimate population health status in North America. Chapter 5 presents the econometric results from the demand for foods and population health status estimations. Chapter 6 discusses policy implications and suggestions. Finally, Chapter 7 concludes with a summary, conclusions, and limitations of this thesis.

CHAPTER 2

2. Background

This chapter begins with an overview of the incidence and burden of chronic illness in Canada, the United States (U.S.), and the European Union (E.U.) and how that has contributed to growth in the functional foods and natural health products (NHPs) industry. The regulatory frameworks in Canada, the U.S., and the E.U. are chosen for comparison because the U.S. and the E.U. are two of the largest markets for functional foods (Leatherhead 2014) and they are important trading partners for Canada's functional food and natural health product sector (AAFC 2014). Statistics Canada (2013a) estimates that half of the export revenues in the Canadian functional foods and NHPs industry was from trade with the U.S., followed next by the E.U. (AAFC 2014). A brief overview of the current estimates of the size of the functional foods industry is provided. Since the functional foods and NHPs industry is relatively new, data on market size and performance is limited. In addition, the available estimates are broad due to a lack of consensus on the definitions for functional foods and NHPs.

Next, this chapter reviews the different definitions and regulatory frameworks for functional foods, NHPs, and health claims in Canada, the U.S. and the E.U. Since functional foods are the focus of this thesis, only a brief discussion of the regulations for NHPs is provided for each country. It is important to note that Canada, the U.S. and the E.U. use some of the same terms (e.g., health claims), but they don't necessarily have the same definition, meaning, or regulatory structure. This chapter defines the different terms and regulations specified in each country and how they compare to one another. After the overview of each country's regulatory frameworks, the Canadian terms for functional foods, NHPs, health claims and related concepts will be used for the remainder of the thesis for simplicity and ease of reference.

Last, the impacts of dietary fats and fruits and vegetables on health are discussed because they relate to the top two chronic illnesses (CVD and cancer) in Canada and the U.S. and they relate to approved health claims in Canada and the U.S. Specifically, this section concludes with a discussion of the different types of dietary fats, their sources, and how dietary fats affect health and the impacts of fruit and vegetable consumption on health. In addition, this section outlines how knowledge about the health impacts of dietary fats and fruit and vegetable consumption has evolved over time.

2.1 Burden of Chronic Illness and the Functional Food Industry

Chronic illness is a global issue with significant economic and social burdens. The economic impacts of chronic illness include both direct costs, such as hospital and drug expenditures, as well as indirect costs, such as lost productivity in the labour market (Public Health Agency of Canada 2014). There are also social costs that cannot be measured such as physical and emotional pain caused by illness and a decreased quality of life. In 2015, 70% of deaths globally were attributed to chronic disease, also known as non-communicable diseases (NCDs) (WHO 2014). CVDs, cancers, diabetes, and chronic respiratory illnesses are the top four causes of NCD deaths (WHO 2014). In 2015, CVD accounted for 45% of NCD deaths and cancer accounted for 22% (WHO 2014).

In Canada, the two leading causes of death, cancer and heart disease, were responsible for 49.6% of all deaths in 2011 (Statistics Canada 2015). In 2008, it was estimated that the largest portion of direct costs associated with illness and injury in Canada was due to CVD, which accounted for 6.8% of total healthcare costs (Public Health Agency of Canada 2014). Other chronic illnesses such as cancer and diabetes also accounted for significant portions of direct healthcare costs (2.2% and 1.3%, respectively) (Public Health Agency of Canada 2014).

Similarly, heart disease and cancer are the leading causes of death in the United States (CDC 2017a). In 2014, these two chronic illnesses were responsible for 46% of all deaths in the U.S. (CDC 2017a). In addition to heart disease and cancer, five other chronic diseases made it into the top ten causes of death in 2014 (CDC 2017a). It is estimated that treatment of these chronic illnesses is responsible for 85% of the total healthcare expenditures in the U.S. (Dietz, Douglas and Brownson 2016). In 2012, the direct and indirect costs of CVD and stroke alone was estimated to cost 15% of total healthcare expenditures in the United States (Mozafarian et al. on behalf of the American Heart Association Statistics Committee and Stroke Statistics Subcommittee 2016).

As for the European Union, annual premature death from the four major NCDs, CVD, cancer, diabetes, and respiratory diseases, occurs at a rate of approximately 200 per 100,000 working age population (age 25 to 64) (OECD/EU 2016). It is estimated that the economic loss associated with these deaths is approximately 0.8% of GDP in the E.U (OECD/EU 2016). Clearly, chronic illness has placed significant economic burdens on societies around the world.

However, research has shown that the risk for many of these chronic diseases, such as heart disease and cancer, can be significantly reduced through the adoption of a healthy diet and balanced lifestyle (Dietz, Douglas and Brownson 2016; WHO 2003; American Heart Association 2017a). Knowledge about the link between diet and health has led to increased interest from both consumers and health authorities in the adoption of a healthy diet as a means of improving well-being. Approximately 86% of Americans indicated they were interested in learning more about health foods (IFIC 2013) and recognized organizations such as the WHO, the American Heart Association, and the CDC now recommend adopting a healthy diet as part of a preventative care strategy (WHO 2003; American Heart Association 2017a; CDC 2017a).

An increased public awareness about the interaction between diet and health, a desire to improve well-being, and efforts by public health authorities to reduce rising public healthcare costs have been major drivers of substantial growth in the functional foods industry (Ohama, Ikedo, and Moriyama 2006; Thompson and Moughan 2008). Functional foods are foods with extra health benefits (Hobbs et al. 2014). Another closely related product is 'natural health products' (NHPs), which are concentrated food products with health benefits that are sold in dosage form (AAFC 2017a). Current market estimates of the size of the health food industry cover a broad range due to a lack of consensus regarding the definitions of functional foods and natural health products (Stein and Rodriguez-Cerezo 2008). In 2010, Euromonitor estimated the global market for functional foods to be worth USD $168 billion (Vicentini, Liberatore, and Mastrocola 2016). By 2013, growth in the international functional foods and health products industry exceeded the conventional processed food market at an estimated rate of 8% to 14% annually (AAFC 2014).

In 2001, the Nutrition Business Journal estimated that the three largest markets for functional foods were Japan (estimated to be worth EUR 21.8 billion), the USA (EUR 20.7 billion), and Europe (EUR 20.1 billion) (Stein and Rodriguez-Cerezo 2008). By 2010, North America was estimated to account for 25% of the global revenues while the E.U. accounted for 19% (Vicentini, Liberatore, and Mastrocola 2016). From 2012 to 2013, the annual growth rate of the functional foods and natural health products industry was 4.6% in North America and between 2.8% and 10.2% in different regions across Europe (Vicentini, Liberatore, and Mastrocola 2016). In Canada, revenues for the Canadian functional foods and natural health product sector generated approximately CAD $16.4 billion in 2011 (Khamphoune 2013) compared to the estimated global market revenues of $168 billion (Vicentini, Liberatore, and Mastrocola 2016).

2.2 Functional Foods: Definitions and Regulations

To improve access to credible information, ensure public safety, and increase public awareness about the health benefits associated with the consumption of functional foods, governments have developed health claim policies (Health Canada 2016c). While the definition of 'health claims' is specific to every country, they are generally understood to be statements that indicate a relationship exists between the consumption of food and health (Health Canada 2016c). The main goal of health claim policies is to help consumers make better dietary choices, improve population health, and reduce the direct and indirect economic burdens associated with diet-related illnesses that are placed on society each year.

2.2.1 Canada

In Canada, functional foods are defined as "foods enhanced with bioactive ingredients and which have demonstrated health benefits" (AAFC 2015, website). Functional foods come in a variety of forms including non-altered products that naturally contain elevated levels of bioactive ingredients, such as blueberries containing antioxidants, or they can be modified through methods such as fortification, enrichment, or genetic modification (AAFC 2016; AAFC 2014). Fortification and enrichment of foods involves adding important amino acids or vitamins and minerals to foods to help consumers achieve a well-balance nutrient profile in their diets (CFIA 2016b). For example, enriching fruit juices with calcium to help consumers reach adequate levels of calcium in their diets (EUFIC n.d.). Genetic modification involves manipulating the genetic material of plants and animals using specialized technologies (WHO 2014) to create new foods that have added health benefits (AAFC 2017b). An example of a genetically modified (GM) functional food is 'Golden Rice' (Dubock 2014). Golden Rice is rice that has been genetically modified to contain higher levels of beta-carotene, which is essential for vitamin A synthesis in the body, than contained in traditional rice varieties (Dubock 2014).

Another related product to functional foods is natural health products (NHPs)[1]. NHPs are defined in Canada as naturally sourced supplements sold in dosage form and are used for improving or maintaining good health, reducing the risk of disease, and restoring body function (AAFC 2017a). NHPs are created by extracting, purifying, grinding or drying naturally occurring substances found in a variety of plant, animal, microorganism and marine sources (Health Canada 2016a; AAFC 2017b). They are sold in dosage form and come in tablets, creams, ointments, drops and include vitamin and mineral supplements (Health Canada 2016b).

In Canada, there are different types of nutrition and health information that are permitted on foods and NHPs. First, as of 2005, most prepackaged foods must have a mandatory nutrition facts table (NFT)[2] (Government of Canada 2015). A NFT is a table on prepackaged food products that provides consumers with information on serving sizes, calories, and the percentage daily values of 13 required nutrients plus any additional optional nutrients (Government of Canada 2015). Percentage daily values indicate the amount of nutrients that is consumed in one serving of the food as a percentage of the recommended daily intake.

[1] Natural health products were known as nutraceuticals in Canada until 2001.
[2] There are a few prepackaged products that are exempt from carrying a NFT such as individually sold one-bite confectionaries, milk sold in reusable glass containers, fresh produce, and raw meats.

In addition to the mandatory NFT, foods may voluntarily carry various types of claims. In Canada, claims that can be made on foods are categorized under two broad categories as either health claims or nutrient content claims. Health claims are defined as any statement on labels or in advertising that directly or indirectly indicates a relationship between the consumption of a food and health (CFIA 2016c), for example, "*a diet low in saturated and trans fat may reduce the risk of heart disease*" (Health Canada 2016c). Nutrient content claims are statements that indicate the quantity or presence of a nutrient or the amount of energy provided by a food (e.g., "*excellent source of calcium*" or "*zero Calories*") (CFIA 2016d).

Health Canada further defines four subcategories of health claims that are permitted on foods. The four types of health claims are 1) general health claims; 2) function claims; 3) therapeutic claims; and 4) disease risk reduction claims (AAFC 2012; CFIA 2016c). General health claims provide broad dietary guidance in line with Canada's Food Guide recommendations and do not reference health effects. An example of a general health claim is, "*part of a healthy diet*" (CFIA 2016c). Function claims describe how consuming a specific food or food constituent can have positive effects on normal body functions. For example, the "*consumption of 1 cup of green tea helps to protect blood lipids from oxidation*" is an acceptable function claim in Canada (AAFC 2012). Therapeutic claims indicate the treatment of a disease or a body function through the consumption of a food or food constituent (CFIA 2016c), such as "*ground (whole) flaxseed helps lower cholesterol*" (Health Canada 2014). Lastly, disease risk reduction claims state a relationship between the consumption of a food or its constituents and a reduction in the risk of a specific diet-related illness (CFIA 2016c). An example of a disease risk reduction claim is "*a diet low in saturated and trans fat may reduce the risk of heart disease*" (Health Canada 2016c).

In addition, there are two further subcategories of function claims: nutrient function claims and probiotic function claims (CFIA 2016c). Nutrient function claims explain the specific effects of nutrients on the normal development, growth and functioning of the body (CFIA 2016c). For example, products containing sufficient levels of iron may use the nutrient function claim "*factor in red blood cell formation*" and "*helps build red blood cells*" (CFIA 2016c). Foods permitted to use nutrient function claims may also use a type of nutrient function claim called 'general nutrient function claims'. General nutrient function claims are broad claims that indicate certain nutrients maintain "good health" or "normal growth and development" (CFIA 2016c). For example, a product containing the required levels of iron may also use the general nutrient function claim "*iron is a factor in the maintenance of good health*" or "*iron is a factor in normal growth and development*" (CFIA 2016c).

The second subcategory of function claims, probiotic function claims, describe the health benefits of the consumption of microorganisms (CFIA 2016c). There are two types of probiotic claims in Canada: non-strain-specific and strain-specific. Non-strain-specific probiotic claims are claims that indicate the general effects of probiotics on body function without reference to a specific strain of bacterial species. For example, "*contains probiotics that contributes to healthy gut flora*" (CFIA 2016c). Strain-specific probiotic claims refer to the health benefits of a specific strain of bacterial species. Health Canada does not currently have an example of a strain-specific probiotic claim as none have been approved thus far (CFIA 2016c).

In Canada, the regulations and definitions for functional foods, NHPs, health claims, and nutrient content claims are governed by the *Food and Drugs Act* (Health Canada 1998). The *Food and Drugs Act* legislates safety, quality, and labeling standards for food and drugs sold in Canada (AAFC 2012). Under the *Food and Drugs Act*, functional foods are regulated as foods and NHPs are regulated as a subset of drugs under the Natural Health Products Regulations (Health Canada 2016b). The *Food and Drugs Act* regulations are jointly governed by Health Canada, the Canadian Food Inspection Agency (CFIA) and Agriculture and Agri-Food Canada (AAFC) (AAFC 2012). Health Canada develops health and safety regulations, the CFIA enforces those regulations as well as develops non-health and safety-related labelling policies, and AAFC helps the industry to understand and navigate the various rules and policies.

Under the *Food and Drugs Act*, health claims and nutrient content claims made on foods are both voluntary and generic (Health Canada 2010). Generic claims are claims that, once approved, may be used on any product provided the product satisfies the criteria to carry the claim. Health claims are also permitted on NHPs, but, in contrast, health claims made on NHPs are product-specific and mandatory in order to inform consumers how to appropriately use the products (NHPD 2006; Health Canada 2016b). Product-specific claims are claims that are reviewed on a case-by-case basis and approved for use on specific products only. Health claims on NHPs must link the product to a health condition or disease except for those diseases referred to in Schedule A of the *Food and Drugs Act*[3] (NHPD 2006). Nutrient content claims do not apply to NHPs.

While all health and nutrient content claims for use on foods are generic once approved, there are some differences in the approval processes for each type of claim. General health claims do not follow explicit regulations but, like all types of claims in Canada, are subject to Subsection 5(1) of the Food and Drugs Act (Health Canada 2016c; L'Abbe et al. 2008).

[3] See Appendix 2 for a list of the diseases listed in Schedule A of the Food and Drugs Act

Subsection 5(1) indicates that all claims must be factual, accurate, and not misleading. In addition, general health claims must give broad dietary guidance that corresponds with the Canada Food Guide recommendations (CFIA 2016c). Health Canada does not review or approve new general health claims and manufacturers do not need pre-market authorization to use general health claims (CFIA 2016c).

As for function claims, Health Canada requires pre-market review and approval of new function claims (CFIA 2016c). For new function claims to be approved, the claims first must meet the acceptable standards of evidence outlined by Health Canada. First, the target consumer must be able to consume the amounts of the food necessary to achieve the beneficial effect as part of a typical diet (CFIA 2016c). Second, the claims must clearly indicate a specific physiological effect. Last, function claims must not indicate the prevention or treatment of a disease or illness or their symptoms (CFIA 2016c). Once approved, function claims become generic and may be used without premarket authorization. There are currently 4 function claims that have been reviewed and approved by Health Canada (CFIA 2016c; Health Canada 2016d). A list of the approved function claims can be found in Appendix 5.

The approval process for new nutrient function claims and probiotic claims is similar to the approval process for function claims. New nutrient function claims are evaluated and approved if the scientific evidence in support of the claim is accepted by an authoritative scientific agency, such as the Institute of National Academies of Science, and reflects agreement among the scientific community about the health benefits (CFIA 2016c). Once approved, new nutrient function claims become generic and are added to the Table of Acceptable Nutrient Function Claims. Currently, there are 28 accepted nutrients that are each recognized to have several different beneficial effects on the body (CFIA 2016c). In addition, Health Canada permits the use of general nutrient function claims on foods containing any of the 28 accepted nutrients[4]. Manufacturers do not need pre-market authorization to use any of the approved nutrient function claims or general nutrient function claims. A list of the approved nutrient function claims can be found in Appendix 5.

Similarly, Health Canada also approves new probiotic function claims based on sufficient evidence in support of the claim (CFIA 2016c). Once approved, these generic claims are either added to the list of acceptable strain-specific claims or non-strain-specific claims depending on the type of claim. Producers do not need pre-market authorization to use any approved generic probiotic function claims. Currently, there are 16 approved non-strain-specific claims and no approved strain-specific claims (CFIA 2016c). A list of the approved non-strain-specific probiotic claims can be found in Appendix 4.

As for therapeutic and disease risk reduction claims, new claims must undergo an in-depth evaluation and approval process by Health Canada to ensure their validity prior to use in the market (Health Canada 2016c). Approval of new disease risk reduction and therapeutic claims is granted if the scientific substantiation to support the claim is found to be comprehensive, well-established, systematic, and transparent (Health Canada 2009). Submissions for new claims also must show that the food or food constituent needed for the beneficial effect can be consumed as part of a normal diet. If the health claim relates to a Schedule A disease, then an amendment to the *Food and Drugs Regulations* must be made prior to approval. Once approved, disease risk reduction and therapeutic claims are generic and producers do not need pre-market authorization to use any of the approved

[4] General nutrient function claims indicate the approved nutrient is either 1) "*a factor in the maintenance of good health*" or 2) "*a factor in normal growth and development*".

claims (Health Canada 2016c). However, manufacturers must comply with specific wording, formatting, and language requirements for the health claims. There are currently 15 approved disease risk reduction/therapeutic claims available for use on foods in Canada (Health Canada 2016b). A list of the approved disease risk reduction and therapeutic claims can be found in Appendix 5.

As for nutrient content claims, Health Canada currently has defined 13 categories of nutrient content claims (CFIA 2016d). Each of the 13 categories has several types of generic nutrient content claims that can be used on foods. New nutrient content claims are approved at the discretion of Health Canada. Manufacturers can use any of the approved generic nutrient content claims without pre-market authorization. However, nutrient content claims must also follow prescribed wording requirements determined by Health Canada (CFIA 2016d). A list of the approved nutrient content claim categories can be found in Appendix 5.

2.2.2 United States

Unlike Canada, the United States does not have a legal definition for functional foods or NHPs, although the terms are commonly used and acknowledged within the industry (FDA 2016d; Hobbs et al. 2014). While functional foods are not defined by law, the U.S. Food and Drug Administration (FDA), recognizes that certain foods provide extra health benefits and regulates the types of health claims that can be made on these foods. In addition, the FDA refers to what are known as 'natural health products' in Canada as 'dietary supplements' in the U.S. Dietary supplements are defined as vitamins, minerals, enzymes, amino acids, and herbs that are sold in dosage form (FDA 2017; FDA 2016c).

The FDA defines and legislates different types of nutrition information that is permitted on foods and dietary supplements. First, like Canada, most prepackaged foods must contain a mandatory NFT[5]. In addition to the NFT, the FDA defines three types of claims that can be made on foods and dietary supplements. Those claims are defined as 1) structure/function claims, 2) health claims, and 3) nutrient content claims. First, structure/function claims are defined as a statement that refers to the effects of a food or dietary supplement on the normal functioning of the body (FDA 2016c). In Canada, these types of claims are referred to as 'function claims'. Second, the FDA defines health claims as statements that indicate a relationship between a food, food constituent, or dietary supplement and the risk of a disease (FDA 2016c). In Canada, these types of claims are defined as 'disease risk reduction claims'. Last, the FDA defines nutrient content claims as claims that describe the quantity or presence of nutrients in a food or dietary supplement (FDA 2016c; FDA 2005). This is the same definition for nutrient content claims in Canada.

Foods and dietary supplements are regulated by the U.S. Food and Drug Administration (FDA) under the *Federal Food, Drug and Cosmetic Act* (FDA 2016a; Hobbs et al. 2014). Under these regulations, functional foods are regulated as conventional foods and dietary supplements are regulated under a separate set of regulations than conventional food and drugs (FDA 2016d) known as the Dietary Supplement Health and Education Act of 1994 (DSHEA) (FDA 2016a). The *Federal Food, Drug and Cosmetic Act* also governs the use and approval processes of structure/function claims, health claims and nutrient content claims made on foods and dietary supplements.

In that regard, the FDA does not directly regulate, review or approve new or existing structure/function claims made on foods or dietary supplements (FDA 2016c). However,

[5] Like Canada, a few foods are exempt from the mandatory NFT in the U.S. such as foods that are insignificant sources of nutrients, foods that are shipped in bulk for further processing, and fresh produce and seafood.

as with all types of claims, structure/function claims must follow certain standards and guidelines outlined in the *Federal Food, Drug and Cosmetic Act* (FDA 2013a). Those standards indicate that claims must be supported by scientific evidence and must be truthful and not misleading. In addition, the following conditions apply to structure/function claims when they are used on dietary supplements. First, a disclaimer must be included on the dietary supplements stating the claim has not been evaluated by the FDA (FDA 2016c). Second, structure/function claims on dietary supplements can not refer to the treatment, prevention, or cure of diseases. Last, manufacturers of dietary supplements must submit a copy of the new claim for review to the FDA within 30 days of marketing the product (FDA 2016c).

As for health claims, all new health claims must be reviewed and approved by the FDA prior to use on foods and dietary supplements (FDA 2016c). Once approved, health claims become generic and manufacturers do not need pre-market authorization to use any of the approved health claims. However, the FDA requires the approved health claims follow specific wording, formatting and language criteria. One notable difference to Canadian regulations for the comparable group of 'disease risk reduction/therapeutic claims' is that there are three different methods in which the FDA can approve new health claims. The first method is under the under the Nutrition Labeling and Education Act of 1990 (NLEA) (FDA 2016c). The second method of authorization of health claims is under the Food and Drug Administration Modernization Act of 1997 (FDAMA). The third method of authorization of new health claims involves the use of qualified health claims. The differences among the three methods of authorization is the level of scientific substantiation required for approval of new health claims.

NLEA authorized health claims require the highest level of scientific substantiation (FDA 2016c). Approval of new NLEA authorized health claims is based on an in-depth evaluation of the relevant scientific literature and, if the level and strength of the evidence satisfies the Significant Scientific Agreement (SSA) standards[6], then the FDA will grant approval to use the claim (FDA 2016c). The FDA can independently choose to review the scientific literature related to a new health claim or can review new health claims because of receiving a health claim petition. The FDA has currently authorized 12 generic NLEA authorized health claims for use on foods[7] (FDA 2013c).

Next, the FDA can approve new FDAMA authorized health claims if they are based on an authoritative statement made by the National Academy of Sciences or certain scientific departments of the U.S. government (FDA 2016c; FDA 1998; Hobbs et al. 2014) rather than providing an in-depth review of the scientific evidence (FDA 2016c). There are currently five generic FDAMA authorized health claims (FDA 2013c)[8]. Manufacturers do not need premarket authorization to use any of the generic FDAMA health claims.

Under the third method of authorization, the FDA can permit the use of qualified health claims when research in support of a new health claim is either not based on authoritative statement or is not yet comprehensive enough to provide evidence that satisfies the requirements of the SSA (FDA 2016c). This method of authorization requires the least amount of scientific substantiation. Manufacturers can submit qualified health claim petitions to the FDA requesting a review of the limited evidence supporting the new claim.

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[6] The SSA standards are based on agreement among qualified experts that the totality of the scientific evidence supports the claim and that the research has been conducted in a reliable, systematic and well-designed manner (IFT n.d.).
[7] A list of the approved NLEA authorized health claims can be found in Appendix 6.
[8] A list of approved FDAMA authorized health claims can be found in Appendix 6.

If the FDA deems the substantiation to be sufficient and reliable, they may approve new generic qualified health claims with the requirement that it contain qualifying language stating the evidence is limited (FDA 2016c). There are the currently 18 approved qualified health claims (FDA 2014)[9].

The U.S. regulations for nutrient content claims are like those in Canada. New nutrient content claims are approved at the discretion of the FDA (FDA 2013a). All approved nutrient content claims are generic and manufacturers do not need premarket approval to use existing claims (FDA 2013). However, nutrient content claims must follow specific wording, placement and visual representation (FDA 2016c). Currently, only claims authorized under the Code of Federal Regulations (21 CFR 101.13) are permitted for use on foods and dietary supplements (FDA 2013a; Hobbs et al. 2014).

2.2.3 European Union

Like the U.S., the E.U. does not legally define functional foods but recognizes that some foods that are consumed as part of a normal diet have extra health benefits (EUFIC 2006; Stein and Rodriguez-Cerezo 2008). As for NHPs, the European Commission (EC) uses the term 'food supplements' to describe a similar type of product. Food supplements are defined in the E.U. as "concentrated sources of nutrients (or other substances) with a nutritional or physiological effect" (EC 2017b, website) that are sold in dosage form (EC 2017b).

The EC defines and regulates various types of health and nutrition information that can be used on food and food supplements. In the E.U., a NFT is compulsory on most prepackaged food products as of December 2016 (EC 2017). Prior to that time, a NFT was

[9] A list of the approved qualified health claims can be found in Appendix 6.

required only when claims were present on labels. Like Canada, the E.U. also has two broad categories of claims that can be made on foods and food supplements: health claims and nutrition claims. Health claims are statements that imply a relationship between the consumption of food and health (EC 2017a). Nutrition claims (known as nutrient content claims in Canada and the U.S.) are defined as statements that suggest a food is beneficial to health because of its nutrient profile or calorific value (EC 2017d).

The E.U. further defines three subcategories of health claims: 1) function claims, 2) risk reduction claims, and 3) claims referring to children's development (EC 2017a). Like Canada, function claims refer to the relationship between a food or its constituents and the normal growth, development and functioning of the body including psychological and behavioural functions (EC 2017a). There are two types of function claims in the E.U.: general function claims and new function claims. General function claims, which are similar to 'nutrient function claims' in Canada are generic claims that refer to the well-established and widely recognized role of nutrients or food constituents and the normal functioning of the body (EFSA n.d.(c)). New function claims are product-specific claims that are based on emerging scientific research and assessed on a case-by-case basis after the submission of a dossier to the EC (EFSA n.d.(d)).

Risk reduction claims are generic claims that indicate the relationship between consuming a food or its constituents and the reduced risk of disease (EC 2017a). These types of claims are regulated as 'disease risk reduction claims' in Canada and 'health claims' in the U.S. Last, health claims referring to children's development are claims that refer to the normal growth and development in children (EC 2017a). Canada and the U.S. do not have a similar category of claims. However, in Canada, legislation permits health claims on foods intended for children under the age of two except for disease risk reduction claims, therapeutic claims, and function claims about folate and fetal neural development, which are strictly prohibited (CFIA 2016c). In the U.S., the FDA also permits generic health claims on infant food (FDA 2016e). However, like all other health claims in the U.S., new claims must be reviewed and approved by the FDA prior to use and manufacturers do not need premarket authorization to use approved claims (FDA 2016e).

Before 2006, legislation for health and nutrition claims permitted on foods and food supplements in the E.U. was regulated by individual member states (Hoad 2011; Hobbs et al. 2014; EC 2017c). However, only a few E.U. countries had explicit regulations governing the use of health and nutrition claims on foods, for example, Sweden and the United Kingdom (Malla, Hobbs, and Sogah 2013). To improve the flow of goods, reduce implicit barriers to trade (EC 2015), and establish a consistent standard for the authorization of health claims (Hoad 2011), the EU introduced Regulation (EC) 1924/2006 in 2006, and the regulations came into effect on July 1, 2017 (EC 2017c). Regulation (EC) 1924/2006 unified health and nutrition claim legislation across all member states and gave authority over claims to the European Commission (EC) in accordance with the opinions of the European Food Safety Authority (EFSA) (EC 2015). The EFSA was established to assess and manage risks associated with food safety and was tasked with the role of providing independent assessments and opinions based on the totality of the available scientific literature supporting health claims (Hoad 2011).

Under Regulation (EC) 1924/2006, both functional foods and food supplements are regulated as foods (EFSA n.d.(b)). The regulations permit the use of health claims on both types of products whereas nutrition claims are for use on foods and not food supplements. The regulations require labels on food supplements to follow a few other specific requirements. First, claims on food supplements may not indicate or reference the treatment or cure of any disease (EFSA n.d.(b)). Second, the labels must indicate the key nutrients in the product and the nature of those nutrients. Last, labels must indicate the recommended daily dosage of the supplement.

In the E.U., authorization of new general function claims (referred to as nutrient function claims in Canada) depends upon a general consensus among the scientific community about the role of nutrients on health. Once approved, manufacturers are permitted to use any of the generic general function claims provided their product meets the conditions of use. The EC has currently authorized 229 general function claims and has rejected 1875 claims[10] (EC n.d.). As for new function claims, these product-specific claims are based on emerging scientific research and new claims are approved on a case-by-case basis after the submission of a dossier to the EC (EFSA n.d.(d)). The EC has currently authorized 5 new function claims and rejected 108[11] (EC n.d.).

Risk reduction claims and claims referring to children's development are highly regulated by the EC and EFSA to ensure that the messages they convey are reliable, credible and easy for the average consumer to comprehend (EC 2017a). The application process for new risk reduction claims and claims referring to children's development involves several different government departments (EC 2017a). First, dossiers are submitted to member country authorities to check for completeness of the application. Next, they are forwarded to the EFSA for assessment and a final decision is published by the EC after it has been further reviewed by the Standing Committee on the Food Chain and Animal Health (EC

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[10] Authorized and non-authorized general function claims as of September 2017. A list of authorized health claims can be found on the EU Registrar for Nutrition and Health Claims (http://ec.europa.eu/nuhclaims/?event=search).

[11] Authorized and non-authorized new function claims as of September 2017. A list of authorized health claims can be found on the EU Registrar for Nutrition and Health Claims (http://ec.europa.eu/nuhclaims/?event=search).

2017a). Prior to authorizing disease risk reduction claims, the EFSA reviews the totality of the scientific literature to ensure it is comprehensive, systematic and reliably demonstrates the claimed relationship (EC 2017a). Once approved, risk reduction claims and claims referring to children's development become generic and may be used without premarket authorization. There are currently 10 different authorized risk reduction claims and 24 non-authorized risk reduction claims[12].

As for nutrition claims (i.e.,, 'nutrient content claims' in Canada and the U.S.), only those generic claims that are listed in the Annex of Regulation (EC) 1924/2006 are allowed on foods (EC 2017d). There are currently 14 broad categories of generic nutrition claims that are approved for use on foods (EC 2017d)[13]. The EC does not require premarket notification to use existing nutrition claims, but they must comply with the conditions to use the claims.

2.3 Comparison of Regulations

The regulations for functional foods and health claims in Canada, the U.S. and the E.U have many similarities as well as a few notable differences. Claims permitted on foods in each country can be grouped into three main categories (using the Canadian terms and definitions): function claims, disease risk reduction claims, and nutrient content claims. Canada and the E.U. have similar approval processes for new function claims. In Canada and the E.U., all new function claims must be reviewed and approved based on sufficient levels of scientific substantiation by the governing agencies prior to use on foods. Once approved, function claims in Canada and the E.U. become generic and may be used without

[12] Approved claims as of September 2017. A list of the 229 approved claims can be found on the EU Register on nutrition and health claims available at http://ec.europa.eu/food/safety/labelling_nutrition/claims/register/public/?event=search

[13] A list of permitted nutrition claims claims can be found in Appendix 7.

premarket authorization. In contrast, the U.S. permits the use of function claims (referred to as ‘structure/function’ claims in the U.S.) on foods, but does not review or approve them.

As for disease risk reduction claims, Canada and the E.U. (referred to as ‘risk reduction’ claims in the E.U.) also have similar approval processes for new disease risk reduction claims. However, the E.U.’s approach to regulating disease risk reduction claims has focused strongly on the ‘precautionary principle’: to protect the health and safety of the public, precaution should prevail when uncertainty exists (Hoad 2011; Aschemann-Witzel 2011). In this regard, approval processes for new disease risk reduction claims in the E.U. require greater levels of scientific substantiation making the approval process lengthier, resulting in fewer claims being approved than in Canada. Currently, there are only 10 approved disease risk reduction claims in the E.U. compared to 16 in Canada. Both Canada and the E.U. require that the scientific substantiation in support of new disease risk reduction claims be reviewed and approved by the governing agencies prior to use on labels or advertisements. Once approved, these claims are generic and may be used by manufacturers without premarket authorization.

As for disease risk reduction claims, the U.S. has a significantly different approval process than Canada and the E.U. Specifically, the U.S. has three methods for approving new disease risk reduction claims (referred to as ‘health claims’ in the U.S.). The first method is for fully endorsed ‘NLEA health claims’ that require similar levels of scientific substantiation as in Canada and the E.U. The second method is for ‘FDAMA health claims’, which do not require an in-depth review by the FDA but must be based on authoritative statements made by the National Academy of Sciences or certain scientific departments of the U.S. government. Last, the third method involves the use of ‘qualified health claims’. Qualified health claims have significantly reduced the time it takes to get new disease risk reduction claims approved as it requires far less robust scientific substantiation to support the claim. Like disease risk reduction claims in Canada and the E.U., NLEA, FDAMA, and qualified health claims in the U.S. are also generic and manufacturers do not need premarket authorization to use approved claims. In total, the U.S. has approved significantly more disease risk reduction claims (35) than have Canada (15) and the E.U. (10), which is largely a result of the use of qualified health claims. There are currently 12 approved NLEA health claims, 5 approved FDAMA health claims, and 18 approved qualified health claims.

Last, Canada, the U.S., and the E.U. have reviewed and approved a list of generic nutrient content claims that are permitted on foods. New nutrient content claims are approved at the discretion of the respective governing agencies in each country. Manufacturers may use any of the approved generic nutrient function claims without premarket authorization. An overview of the disease risk reduction, function, and nutrient content claims in each country is provided in Appendix 1.

2.4 Dietary Fats and Fruits and Vegetables

Based on their relevance to the top two chronic illnesses and causes of death, the two Canadian health claims that will be analyzed for their impacts on food demand and population health are (1) "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" and (2) "Fruits, Vegetables and Cancer (2000)". To draw comparisons with Canada, the U.S. health claim, "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)", is also analyzed for its impacts on food demand and population health in the U.S.

In that regard, dietary fats are crucial to the body as they help with the absorption of certain vitamins and nutrients and provide energy (American Heart Association 2017a).

However, not all dietary fats are created equal and some can have negative health consequences. There are four main types of dietary fats: saturated fatty acids (SFAs), trans fatty acids (TFAs), monounsaturated fatty acids, and polyunsaturated fatty acids (American Heart Association 2016a). Each type of dietary fat has different properties and impacts on blood cholesterol levels and overall health.

Research on SFAs during the 1980s found that the consumption of saturated fats has negative health consequences (Schleifer 2012). SFAs are considered “bad” fats due to their effects on increasing low density lipoprotein (LDL) cholesterol (i.e.,, bad cholesterol) (American Heart Association 2017b). High levels of LDL blood cholesterol are a major risk factor for heart disease and stroke. Most SFAs are found in animal products such as beef, dairy, and pork (American Heart Association 2017b). Throughout the 1990s, public awareness about saturated fats grew significantly due to extensive published research and related media attention (Wasink and Cheney 2005).

The health consequences of TFA consumption were not well understood prior to the 1990s (American Heart Association 2017c). TFAs are a type of fat naturally found in small quantities in some animal products (e.g., meat, milk, or cheese) (American Heart Association 2017c) or are created when liquid vegetable oils are converted to solid forms using an industrial partial hydrogenation process (American Heart Association 2017c; Ratnayake et al. 2007). During the 1990s, research revealed that the consumption of TFAs posed an even greater danger to health than SFAs (Resnik 2010). This is because TFAs increase total blood cholesterol levels through an increase in “bad” (LDL) cholesterol and a reduction in “good” (HDL) cholesterol (Ratnayake et al. 2007).

Both the search for a substitute for saturated fats (Schleifer 2012) and the lack of understanding about the negative health effects from TFA consumption contributed to the significant rise in TFAs found in processed foods during the 1980s and 1990s (American Heart Association 2017c). While changes to margarine production have led to it now being recognized as containing “heart healthy” fats (e.g., American Heart Association 2017a), during the 1980s and 1990s margarine was a major contributor of dietary TFAs and TFAs accounted for between 20 to 50% of total fat contents found in various margarine brands (Ratnayake et al. 2007).

In contrast to SFAs and TFAs, mono- and polyunsaturated fats are regarded as “heart healthy” fats (American Heart Association 2016b, 2017a). Research has revealed that mono- and polyunsaturated fats reduce levels of LDL (bad) cholesterol, which lowers the risk of heart disease and stroke, and provide essential nutrients and antioxidants to the body. Polyunsaturated fats also provide omega-3 and omega-6 fatty acids, which are fats that cannot be produced by the body but are crucial for maintaining good health (American Heart Association 2016b). Vegetable oils, or “salad” oils, such as olive oil, canola oil, peanut oil, safflower oil are high in monounsaturated fats (American Heart Association 2017a) while soybean oil, corn oil, and sunflower oil are high in polyunsaturated fats (American Heart Association 2016b).

In recent years, significant efforts have been made by public health officials to drastically reduce the consumption of both TFAs and SFAs to mitigate the rising economic burden of heart disease and related illnesses such as high cholesterol, high blood pressure, and stroke. In Canada, the “Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease” health claim was approved in 2000 (Health Canada 2016b) and mandatory labelling of TFA in the nutrition facts table (NFT) came into effect in 2005 (Ratnayake et al. 2007). In the U.S., a similar health claim regarding “Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" was passed in 1993 (FDA 2013c) and, by 2006, the U.S. had passed similar mandatory TFA labelling laws (FDA 2003).

As for fruits and vegetables, research has indicated that adequate consumption of fruits and vegetables can have protective effects against cancer by lowering oxidative damage to DNA and increasing the body's ability to detoxify carcinogens (Key 2010). From 1975 to 1992 there was a significant increase in research about the relationship between fruits and vegetables and cancer (Key 2010). In 1991, a public-private partnership among several health organizations including the National Cancer Institute, the USDA, and the American Cancer Society, launched an educational campaign called "5 A Day" to increase public awareness and encourage the consumption of fruits and vegetables (Food and Nutrition Services 2017). By 1997, the World Cancer Research Fund (WCRF) and Institute for Cancer Research (ICR) released a report that determined there was sufficient evidence to support that the consumption of fruits and vegetables has protective effects against several types of cancer (Health Canada 2000). Based on the 1997 report by the WCRF and ICR, Health Canada approved the health claim, "Fruits, Vegetables and Cancer" in 2000 (Health Canada 2000).

2.5 Summary

Chronic illness consistently has been the leading cause of death in Canada, the U.S. and the E.U. (WHO 2014; Statistics Canada 2015) and places significant economic and social burdens on societies (Public Health Agency of Canada 2014; Dietz, Douglas and Brownson 2016). Research has shown that a healthy diet can be used to mitigate or significantly reduce the risk of many chronic illnesses (Dietz, Douglas and Brownson 2016; WHO 2003; American Heart Association 2017). Rising health care costs and a desire to improve well-being has led to an increased interest from consumers and health authorities in the use of diet as a preventative care strategy and a way to reduce the economic burdens of chronic illness (WHO 2003; Public Health Agency of Canada 2014). Health authorities have begun regulating health claims on foods to provide consumers with accurate, credible, and easy to implement dietary information and to encourage the consumption of healthy foods and reduce rising healthcare costs. Generally, health claims are understood to mean any statement that indicates a relationship between the consumption of food and health.

Canada, the U.S., and the E.U. each define and regulate the types of health claims that are permitted on foods. In general, health claims can be grouped into three main categories: function claims, disease risk reduction claims, and nutrient content claims. The regulatory framework in the E.U. is the lengthiest and most stringent compared to Canada and the U.S. The U.S. is the most relaxed regulatory environment of the three. The major differences occur under the approval processes for new function claims and new disease risk reduction claims. In that regard, Canada and the E.U. require premarket approval of new function claims while the U.S. permits function claims but does not regulate them. As for disease risk reduction claims, the E.U. requires the greatest level of scientific substantiation and has approved the least disease risk reduction claims (14), followed by Canada (16) and then the U.S. (35). The use of qualified health claims in the U.S., which require considerably lower levels of scientific substantiation, has contributed significantly to the rise in approved disease risk reduction claims.

Based on their relevance to the top two chronic illnesses and causes of death, two Canadian disease risk reduction claims will be analyzed for their impacts on food demand and population health: (1) "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" and (2) "Fruits, Vegetables and Cancer (2000)". Similarly, based on its relevance to the top chronic illness and consistency and comparison with

Canada, the U.S. disease risk reduction claim "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" also will be analyzed for its impacts on food demand.

CHAPTER 3

3. Literature Review

This chapter contains a review of the current related literature on functional foods, the demand for foods, and population health status. To provide a greater understanding of the factors that influence the consumption of functional foods, this chapter begins with a review of the "ex-ante" literature on the factors that contribute to consumer acceptance, attitudes, and willingness-to-pay (WTP) for functional foods.

The second section reviews the impacts of advertising, health information from non-advertising sources, such as physicians, family, friends, or articles, and labelling policies on food demand. The purpose of reviewing the demand literature review is to provide insights into how health claims might impact consumer demand for functional foods. Government develops health claim policy to communicate valuable diet related health information to consumers and encourage the consumption of healthier foods. Similarly, advertising is a method for producers to deliver product information to consumers with a goal of influencing product purchases (Dahlen and Rosengren 2016). To develop a broad understanding of the "*ex-post*" impacts of how information affects dietary purchasing patterns, this section first focuses on the impacts of generic and brand advertising on food demand. Generic advertising refers to advertising that is conducted for a whole industry, for example, the "Got Milk?" advertising campaign for the dairy industry (Zheng and Kaiser 2009). In contrast, brand advertising refers to advertising activities for a specific product or brand.

Next, the review of the demand literature focuses on how health information obtained from non-advertising sources impacts the demand for foods. The impacts of health information on food demand is important because it relates directly to the type of information being provided in health claims. Last, the demand section of this chapter reviews the impacts of labels on the demand for foods. This is important because health claims are delivered to consumers on labels and influence them directly at the point of purchase. While the impacts of health claims on the demand for foods has not been specifically studied in the literature, research has focused on how nutrition information, such as NFTs and nutrient content claims (e.g., Mathios 2000; Tiesl, Bockstael and Levy 2001), and health risk information (e.g., Dedah, Keithly, Jr., and Kazmierczak 2011) provided on labels affects the demand for foods. This area of research has used retail scanner data that records prices and volumes of goods sold at grocery stores using point-of-sale systems in the U.S. (Chicago Booth n.d.).

Last, to provide a greater understanding on the ability of diet and health claim policy to improve health status, this chapter concludes with a review of the socioeconomic and lifestyle factors that contribute to health status of the population. Population health often is modeled as a health production function (e.g., Or 2001; Thornton 2002; Shaw, Horrace and Vogel 2005; Joumard et al. 2008). Health production functions consider numerous socio-economic, environmental and lifestyle factors as inputs in the production of health (Or 2001; Auster, Leveson, and Sarachek 1969) and are useful when estimating health status at the aggregate level (e.g., Or 2001; Thornton 2002; Shaw, Horrace and Vogel 2005; Joumard et al. 2008). This section reviews the literature on factors that contribute to population health and the estimation of health production functions.

3.1 Functional Foods

3.1.1 Acceptance and Attitudes

One of the most important factors that contributes to consumer acceptance of functional foods is belief that the foods provide health benefits and credibility of the claimed health benefits (Urala and Lähteenmäki 2004; Verbeke 2005; van Kleef, van Trijp, and Luning 2005). Urala and Lähteenmäki (2004) evaluated consumer attitudes and willingness to use functional foods. The authors surveyed 1158 Finnish consumers on their attitudes and beliefs about probiotic and calcium enriched juices, milk with added calcium, cholesterol-lowering spreads, meats with added fiber, chewing-gum sweetened with xylitol, and energy drinks. They used factor analysis and 3-way ANOVA to analyze the responses. The results show that a perceived reward of improved health most strongly influenced willingness to consume functional foods. In addition, belief that functional foods support well-being and are part of a healthy diet was a significant factor for functional foods that promoted gut health or offered a reduced risk of CVD. Further, the credibility of health information affected intentions to use probiotic products, fiber-enriched products and calcium-enriched products. Compared to males, females believed functional foods were less of a necessity to a healthy diet and that they could not be used to counteract poor diets. In addition, females were not as willing as males to compromise on taste for health as males. As for age, in comparison to older participants, younger consumers were not as willing to compromise on taste for added health benefits, did not view the consumption of functional foods to be as rewarding, nor did they think they could be used to counteract poor dietary decisions.

In another study, Verbeke (2005) also found that belief in the health benefits of functional foods is an essential factor for consumer acceptance. The author evaluated the attitudes and socio-demographic factors that determine consumer acceptance of functional foods in Belgium using a survey of 215 consumers responsible for household grocery shopping in 2001. Bivariate and multivariate probit models were estimated to determine the probability of consumer acceptance. It was found that the main determinant of acceptance of functional foods is belief that the consumption of functional foods provides health benefits. The probability of acceptance was found to increase with the presence of an ill-family member and decrease with increased knowledge of functional foods. No significant relationship between gender, age, education and the presence of children and acceptance of functional foods was found. The results from this study indicate that knowledge and belief play a larger role in acceptance than socio-demographic characteristics of consumers.

Similarly, van Kleef, van Trijp, and Luning (2005) also found that both belief and credibility of the health benefits of functional foods strongly affects intentions to try functional foods. The authors evaluated the preferences and attitudes of 50 Dutch consumers towards 100 different health claim-carrier food combinations. The carrier foods included brown bread, gum, chocolate, margarine, meat replacer, pills, ice-cream, soup, tea, and yoghurt and the health claims included various disease risk reduction claims and function claims. The responses were analyzed with regression analysis and ANOVA. The different food-health benefit scenarios were rated by consumers on credibility, attractiveness, uniqueness and intention to try the product. The results showed that the intention to try functional foods was positively influenced by how credible, attractive and unique the participants perceived the products to be. The attractiveness of the products' health attributes was the most important determinant followed by credibility and then uniqueness. However, the more unique consumers perceived the product, the less credible it became.

Several papers also reported that health claims have significant impacts on consumers' acceptance of functional foods, product evaluations, and product choice (van Kleef, van Trijp, and Luning 2005; van Trijp and van der Lans 2007; Chrysochou and Grunert 2014; Huang and Lu 2016). However, understanding and perceptions of health claims can vary depending on the specific type of claim used and the claimed benefit. In that regard, van Kleef, van Trijp, and Luning (2005) surveyed 124 Dutch consumers on their responses to different health benefits-claim type formats. Survey responses were analyzed using ANOVA. Consumers were asked to rate different carrier food-health benefit combinations on attractiveness, credibility, intentions to purchase and claim believability. The health benefits included reduced incidences of heart diseases, cancer, osteoporosis, dementia, stress, and lack of energy and improved appearance. The carrier foods included yoghurt, margarine, bread, chocolate, soup, tea, gum, and meat replacer. In general, health claims regarding physiological benefits (e.g., heart disease or cancer) were more appealing than behaviour or psychological based benefits (e.g., energy or stress levels). In addition, the attractiveness and believability of different claim types (e.g., disease risk reduction or function claims) depended on the health benefit that was being delivered. For example, a stress-CVD health benefit was better suited to a disease risk reduction claim type while a low energy benefit was better suited to a function claim type. Also, personal experience with health claims increased purchase intentions, product appealing and believability. Overall, the research indicate that specific health benefits are delivered more effectively with certain claim types and personal experience increases receptivity.

In a similar study, van Trijp and van der Lans (2007) examined differences in consumer perceptions and understanding of health claims by surveying across countries. The researchers surveyed consumers from the US (n=1621), the UK (n=1560), Italy (n=1566) and Germany (n=1620) on their perceptions of different health-diet relationships (e.g., CVD and plant sterols) and claim types (e.g., disease risk reduction claim) combinations presented on yoghurt products. Consumers rated the different health benefit-claim type combinations on credibility, product appeal, understanding, and overall perceived healthiness. The structure of the responses was evaluated using principal component analysis. It was found that nutrient content claims were perceived as being most credible and product claims (claims about the benefits of whole product rather than specific ingredients) were perceived as least credible. Claim types also affected understanding of the claimed health benefits but did not affect the product appeal or perceived healthiness. In addition, different claim types were more suitable at delivering certain health messages than others. For example, nutrient content claims relating to CVD were perceived as most difficult to interpret whereas nutrient content claims relating to weight management were the easiest to understand. Consumers also differed across countries in their understanding, trust and perceptions of the health information. Claims about stress were relatively easy to interpret by consumers in Germany and Italy but difficult for consumers in the US and the UK. These results suggest that policymakers might benefit from identifying different consumer segments, and putting less emphasis on regulating claim types and more emphasis on educating consumers about different diet-health relationships.

Further, Chrysochou and Grunert (2014) presented yoghurt and cheese advertisements with varying types of claim to 572 Danish consumers and then asked them about their perceptions of the products. The responses were analyzed using a repeated measures linear mixed model. The results revealed that ‘functional claims’ (statements that indicated the presence of a nutrient or food constituent) increased perceptions of product healthiness. However, functional claims did not appear to have an impact on purchase intentions. In addition, the participant’s level of motivation to engage in healthy behaviors did not appear to influence the use of functional claims when making product evaluations and forming purchase intentions. The authors also found that consumers generally rely more on ‘health imagery’ (visual components on packaging that have health-related meaning) than functional claims and ‘process claims’ (claims about the production methods, e.g., organic), particularly those consumers who are less health motivated. In general, the results from this study suggest that monitoring the use of health imagery in addition to health claims may be a more effective policy strategy for encouraging healthy consumption patterns.

Additionally, Huang and Lu (2016) evaluate how the use of nutrient content claims and product packaging can influence consumer’s perceptions of the utilitarian and hedonic food products. Hedonic foods are defined as those eaten for pleasure, such as ice-cream or chips, whereas utilitarian foods are eaten for a practical purpose, such as consuming water for thirst or yoghurt for health. Using a survey of 120 Canadian participants, the authors used a mixed model of repeated measurements and descriptive statistics to determine how the color of packaging and nutrient content claims influence consumer evaluations of healthiness and purchase intentions of hedonic and utilitarian foods. The results showed that when no nutrient content claims are present, the color of packaging affects health perceptions for utilitarian products but not for hedonic products. In addition, health perceptions were found to influence purchase intentions. When comparing two alternative products, one with a nutrient content claim and one “regular” version without a claim, consumers perceived the products with the claim as healthier only when other visual cues on packaging were consistent. The authors suggest visual cues on packaging should be considered in coordination with claims as they can affect consumer perceptions of healthiness and purchase intentions. This is an important consideration as using appropriate marketing strategies can result in improved dietary patterns.

Further, research has shown that both the presence of health claims and extent at which consumers make use of additional product information affects acceptance, product evaluations and purchase intentions for functional foods (Roe, Levy, and Derby 1999;

Goodman et al. 2012). Roe, Levy, and Derby (1999) studied how consumers evaluate foods and their information search behaviours when health claims and nutrient content claims are present on front-of-package (FOP) labels. Data were obtained from interviews of 1403 primary household grocery shoppers across eight US states and the responses were analyzed using probit and multinomial logit regression analysis. Interviewers recorded whether consumers use only FOP information or both FOP information and the nutrition facts table (NFT) when making purchasing decisions about cereal, lasagna and yoghurt products. The results indicated when claims were present on the label, consumers were more likely to purchase the products and perceived them to be healthier. However, consumers that only used information provided on the FOP were more likely to buy the product compared to those who also used the NFT. In general, consumers frequently limit their search for information to FOP labels and the probability of doing so increased when nutrient content claims and health claims were present on the labels. The authors suggested that regulations should ensure products meet certain nutritional criteria and scientific substantiation to qualify for claims as this can lead to healthier purchasing decisions than when only FOP labels are used.

In a similar study, Goodman et al. (2012) studied how FOP sodium content labels affect purchasing decisions for low versus high sodium products. During 2010 to 2011, the researchers randomly divided 430 participants from Canada into one of five experimental groups, in which the degree of detail on FOP labels for sodium in crackers varied across groups (no FOP label to very detailed and color coded FOP labels). Logistic regression analysis was used to determine the factors that contributed to differences in product choice across the five groups. Age, sex, ethnicity, education and income did not have a significant effect on product choice. However, all four groups that received some form of FOP labeling were more likely to choose low sodium crackers than were those in the control group that had no FOP labels. Overall, the researchers found that FOP labels increase consumer awareness about functional foods and can encourage consumers to make healthier dietary choices while sociodemographic characteristics of the participants had little or no relevance.

While "ex-ante" studies have indicated that health claims can be an effective strategy for promoting interest in functional foods, it is argued that not all currently approved health claims are effective at changing consumption patterns for several reasons (Wasink and Cheney 2005; Mariotti et al. 2010). The following descriptive studies discuss the reasons health claims might not be successful in the U.S. (Wasink and Cheney 2005) and the E.U. (Mariotti et al. 2010). Wansink and Cheney (2005) describe possible reasons some approved health claims in the U.S. are more effective than others. The authors suggest that labeling of claims is more effective when used in tandem with other forms of communication, such as advertising or educational campaigns. In addition, effective claims must clearly establish a specific diet-health relationship, indicate a target audience, and clearly communicate the sources of food that are applicable to the claim to ensure the recommendations are easy to implement. Media coverage about the diet-health relationship also can significantly increase public awareness and the impacts of claims. For example, the link between dietary fats and heart disease received a lot of media attention during the 1990s, helping to increase public awareness. Health claims that are personally relevant also can have great success. However, this appears to be dependent on the relative weight of the health benefit. In some cases, consumers might be more heavily influenced by health claims that offer substantial health benefits compared to health claims they know have relatively trivial benefits.

Similarly, Mariotti et al. (2010) discuss the reasons that claims in the E.U. might not be successful and might result in confusion among consumers. First, the wording of claims might not be fully understood by the average consumer or could be misinterpreted. Second, the actual quantity of specific nutrients required for a balanced diet might not be known or consumers might not appropriately implement the suggestions in the claim. Third, the important role of other genetic, environmental and dietary factors not included on the claim can mislead consumer perceptions of the benefits. Last, consumers might not be aware that some health claims are meant to target a specific audience rather than the general public. The authors suggest that health claims should provide general dietary guidance towards certain food groups rather than indicating specific health benefits on specific products. In addition, the wording of health claims should provide consumers with information on how to implement the guidelines. Other solutions for improving public health include banning certain claims or limiting the number of allowable claims, restricting wording on claims and including general disclaimers.

In addition to the use of health claims, it also has been shown that the personal relevance of the claimed health benefits and being health conscious are significant determinants of acceptance of functional foods (Peng et al. 2006; Ding, Veeman and Adamowicz 2015). Peng et al. (2006) evaluated the factors that contribute to consumer acceptance and intentions to purchase conjugated linoleic acid (CLA)-enriched dairy products. Researchers have found that CLA, a naturally occurring substance found in dairy products, might contribute to a reduced risk of some diet-related illnesses. Peng et al. (2006) surveyed 803 Canadian consumers on their attitudes and knowledge of CLA-enriched dairy products and evaluated the responses using a probit model. The results showed that previous experience with similar functional foods increased the likelihood of trying CLA-enriched products.

Like previous studies, belief in the claimed health benefits also increased the likelihood of trying these products by 3% to 5.6%. In addition, the intentions to try CLA-enriched products were 3.6% to 7.9% greater for consumers more concerned with cancer prevention and 5.8% greater for those more concerned with diabetes prevention. As for sociodemographic variables, gender, education and geographic location also did not significantly affect purchase intentions. However, middle-aged consumers (35-54) expressed more interest in CLA-enriched products. Overall, the results suggest that CLA-enriched products might be most successful in a target group of consumers aged 35 to 54 who are interested in improving health. In addition, the believability and familiarity of health claims might increase the success of these products.

Additionally, Ding, Veeman and Adamowicz (2015) examined how belief in the control of one's health as well as trust in the food industry affect consumer choice of functional canola oil. Survey responses from 1009 Canadians with regards to genetically engineered canola oil with increased levels of omega-3 content was analyzed with a logit model. The results showed that those who believe they are in control of their health tend to be more accepting of omega-3 enhanced canola oils. In addition, trust in the food industry is a significant determinant for acceptance of functional canola oil. The results further showed the appeal of omega-3 enhanced canola might be reduced by the negative perceptions associated with GM products. However, negative views can be offset by generalized trust in the food system. The authors also analyzed WTP and found consumers are willing to pay the most for the attribute of being a Canadian product ($1.45), followed by increased omega-3s ($0.95) and for the attribute of no genetic modification ($0.60). The authors suggest that policy aimed at encouraging healthy dietary choices might be more successful if health messages are used to target specific segments of consumers rather than broadly targeting all consumers.

In that regard, segments of consumers with similar attitudes towards functional foods can be identified based on similar sociodemographic characteristics (Herath, Cranfield and Henson 2008). Herath, Cranfield and Henson (2008) evaluated the consumer characteristics that influence receptivity towards functional foods. Using a sample of 1753 Canadians, two groups of consumers were identified based on similar receptivity to health foods and supplements using activities, interest and opinion cluster analysis. Researchers asked questions about attitudes, motivations, and knowledge of functional foods to serve as a proxy for receptivity. The results indicate that knowledge of the effects of health foods and supplements on disease risk-reduction was quite low over the sample, although it was slightly higher for women than for men. In addition, the group that was more receptive to functional foods was, on average, older, from lower income families, and had lower levels of formal education.

Regardless of consumers' beliefs in the benefits of consuming functional foods, many individuals may not be willing to forgo taste for added health benefits in foods (e.g., Verbeke 2006; Hoppert et al. 2013; Yi et al. 2014; Miklavec et al 2015). Changing the nutritional properties of foods can sometimes come at a cost of unusual or unpalatable sensory characteristics. For example, a reduction in sugar or fat contents in yoghurts has been associated with less flavorful products and atypical textures (Hoppert et al. 2013; Miklavec et al 2015) or the addition of omega-3s to eggs are linked to concerns of unappetizing "fishy" flavors and smells (Yi et al. 2014). As a result, studies have focused on determining the impacts of taste on the acceptance and appeal of functional foods.

Verbeke (2006) assessed the consumer characteristics that influence the willingness to compromise on taste for the addition of health benefits in functional foods. The author used descriptive statistics and stepwise multiple regression to analyze survey data of 255 Belgian consumers in 2001 and 205 consumers in 2004. The results showed that in general, Belgian consumers are skeptical of functional foods and unwilling to compromise on flavor. At the beginning of the period, only about 15% of consumers were willing to accept functional foods with unfavorable flavors compared to their conventional counterparts and that number further decreased by approximately 5% by the end of the sampling period. Acceptance towards functional foods in general and willingness to compromise on taste for health was found to be influenced by consumers' belief in the foods' health properties. However, this strength of belief on consumer attitudes appears to decrease over time. Overall, this research suggests that Belgian consumers are unlikely to give up taste for added health attributes.

Similarly, the sensory characteristics of enriched yoghurt products were found to influence attitudes. Hoppert et al. (2013) evaluated how consumer acceptance of yoghurt products is affected when the products are altered to contain increased levels of fiber and reduced sugar content. The authors set up an experimental design and used descriptive statistics to analyze the responses of 704 German university students on their overall acceptance and perceptions of the sensory characteristics of varying fiber and sugar content in yoghurt products. The results showed that sugar levels and fiber content in yoghurt affects the sensory qualities and, thus, affects consumer acceptance. For products with higher fiber levels, acceptance increased when sugar content was higher and the yoghurts were rated as more flavorful. In reduced-sugar yoghurts, the addition of visible fiber (cereals) reduced acceptance when compared to additional fiber that was not visible (inulin) in the yoghurt. These results suggest that acceptance depends on the overall sensory characteristics of the functional foods. In this case, sugar might have helped mask the undesirable sensory characteristics associated with the increased fiber levels. In addition, the source of fiber also changed consumer acceptance towards the functional yoghurt products as it affected the original sensory characteristics. Therefore, focusing on improving general flavor profiles might be a successful strategy for increasing acceptance of yoghurts with altered nutritional compositions.

Additionally, Yi et al. (2014) evaluated the sensory characteristics of omega-3 enriched eggs from hens fed different feeding regimes. The authors conducted a study during 2012 that included variations of flaxseed oil and dried whitebait in the diets of hens as a source of omega-3 fatty acids. The sensory evaluations of 15 Korean graduate students were analyzed using ANOVA. The results showed that based on sensory characteristics (color, flavor, and overall acceptability), eggs produced from hens fed the control diet, which included only the addition of soybean oil, was preferred to eggs produced from hens fed a diet with both flaxseed oil and dried whitebait. In comparison to the control group, the addition of the dried whitebait reduced the overall acceptability of the eggs.

Futhermore, Miklavec et al. (2015) also found that taste is an important factor when making purchasing decisions for functional foods. Miklavec et al. evaluated the factors that influence product evaluations of hypothetical yoghurt products with different claims. Conjoint analysis was used to evaluate the responses of 371 participants from Slovenia on different types of hypothetical yoghurts that either had a fat content claim, sugar content claim, probiotic claim, or fat metabolism claim. The results showed that segments of consumers could be identified based on similar preferences. However, when making purchasing decisions, 91% of consumers agreed that taste was an important factor. One cluster was found to prefer both higher sugar content yoghurts and yoghurts with nutrition claims, suggesting they might be more susceptible to purchase unhealthy products with misleading claims. Another cluster was found to be more “traditional” and preferred higher-fat yoghurts, possibly because they did not want to compromise on taste as 61% of all consumers agreed that fat improved the taste of yoghurt. This “traditional” cluster also tended to put less relevance on claims in general. With regards to type of claims, most consumers preferred claims about fat content and sugar content, although some were receptive to probiotic and metabolism claims.

The perceived fit between functional ingredient (e.g., fiber, omega-3s or vitamins) and its carrier food (e.g., granola bars or yoghurt) also was a significant determinant in the acceptance of functional foods (Krutulyte et al. 2011; Lu 2015). Krutulyte et al. (2011) examined whether acceptance of functional foods depends on the ingredient-carrier combination. The researchers surveyed 959 Danish consumers on their attitudes towards functional foods, level of health concern, and intentions to purchase different products, such as yoghurts, fish products, rye bread, muesli bars and baby meals, that had various added functional ingredients, such as fibre, omega-3s, vitamins and minerals. Using logistic regression analysis, the results showed a preference for certain carrier-ingredients combinations and the perceived fit of the match had the strongest influence on purchasing intentions. The most appealing carriers were yoghurts, rye breads and muesli bars. Ingredients that were perceived as having less of an impact on a product’s sensory experience, such as vitamins, minerals and plant sterols, were preferred to ingredients that were expected to affect flavor, such as omega-3s or fish oils. In addition, the effects of ingredients and carriers were stronger when considered together. For example, yoghurt or baby food paired with added vitamins, and bread or granola bars with added fiber were the most appealing combinations. This suggests that consumers might prefer combinations that are perceived as being more "natural" carrier-ingredient pairings. The probability of purchasing functional foods also was positively influenced by more familiar combinations, greater concerns for health and overall positive attitudes towards functional foods.

Additionally, Lu (2015) also found that perceived carrier-ingredient fit is an important determinant for consumer's purchasing intentions of functional foods. The author used a seven-point Likert scale and descriptive statistics to evaluate the survey responses of 62 Canadian consumers. It was found that the effect of perceived fit is influenced by the level of prior dietary knowledge. The purchase intentions of those who were less knowledgeable about diet and health were influenced more by perceived fit than those who had more knowledge on the subject. The author also investigated how the interaction of health claims and perceived carrier-ingredient fit affects acceptance of functional foods by surveying 93 Canadian consumers on their attitudes and intentions to purchase different products. The results showed that the presence of health claims increased the acceptance of functional foods and decreased the weight placed on perceived carrier-ingredient fit.

3.1.2 *Willingness-to-Pay*

It has been shown that credibility and belief in the health benefits offered by functional foods can significantly increase consumer WTP for functional foods (Maynard and Franklin 2003). Maynard and Franklin (2003) studied consumer WTP for dairy products that are high in CLA. Research has shown that CLA might reduce the risk of some types of cancers. The authors surveyed 111 U.S. participants on their product evaluations and choices between regular dairy products and high-CLA dairy products, both of which had the same flavor profiles. A contingent valuation method was used to determine WTP for regular and high-CLA milk, yoghurt, and butter products. The results showed that, on average, consumers were willing to pay \$0.41/gal more for CLA enriched milk, \$0.38/gal more for CLA enriched butter and \$0.15/eight ounces more for CLA enriched yogurt compared to conventional versions of these products. However, several participants expressed that their WTP for these premiums is dependent on the health benefits of CLA being supported by the medical community. In addition, other factors that were found to contribute to higher levels of WTP are the presence of children in a household and being mindful of one's health. This suggests the importance of credibility in consumer's acceptance and willingness-to-pay for foods with extra health benefits.

In addition, "ex-post" research about the success of functional margarine products containing phytosterols, a naturally occurring compound found in plants, in the E.U., U.K. and U.S. also suggests that consumers are willing to pay more for products with credible health benefits (MarketLine 2012, 2014). Phytosterols have been shown to reduce blood cholesterol levels and help reduce the risk of heart disease. Claims about the benefits of phytosterols have been approved by several different public agencies including the FDA, the EFSA (MarketLine 2014) and Health Canada (Health Canada 2016d), and are also endorsed by groups such as the American Heart Association. The Raisio Group developed margarine that contained phyto stanols, a type of phytosterol, under the product line Benecol and initially introduced it into the Finnish market in 1995 and later into the U.S. and the U.K. The product line has been very successful, particularly in the E.U., where it captured 1.33% of the entire market for all spreadable fats in the E.U. in 2010 (MarketLine 2012). In 2014, research showed that Benecol was selling for more than its conventional counterparts at approximately £7.28/kg compared to £3.70 - £6.20/kg for regular margarines (MarketLine 2014). The continued success of Benecol at higher prices indicates that there is a market for these products and that consumers are willing to pay more for them than the conventional alternative.

Another significant factor for increasing WTP for functional foods is the use of health claims and labelling to provide consumers with additional health information (Van Wezemael et al. 2014; Vecchio, Van Loo and Annunziata 2016; Hwang, Lee, and Lin 2016). Van Wezemael et al. (2014) evaluated consumer preferences and WTP for lean beef steaks in the E.U. when either a single nutrient content claim or both a nutrient content claim and health claim is present on the label. The claims were with regards to either iron, protein, or saturated fats. The authors surveyed 2400 consumers across the U.K., Belgium, the Netherlands, and France (600 per country) and the responses were analyzed with logit models. The results showed that consumers in the UK are willing to pay more for nutrient content claim about protein (5.81 EUR/kg) compared to those in the Netherlands (2.71 EUR/kg) and Belgium (3.42 EUR/kg). However, Dutch, Belgian, and French consumers showed the greatest WTP for nutrient content claims about saturated fats compared to other nutrients (5.78, 5.60 and 6.73 EUR/kg, respectively). In addition, different preferences for certain claim types and benefits were found across consumers within countries. In France, consumers were willing to pay 6.22 EUR/kg more for beef steaks with both a nutrient content and health claim about saturated fats and 2.10 EUR/kg more for those about protein compared to beef steaks with both types of claims about iron. In the Netherlands, nutrient content claims about iron and saturated fats were preferred to those about protein. Overall, the authors concluded that, in general, claims on beef steaks about saturated fats evoked greater WTP than claims about iron and protein.

In addition, Vecchio, Van Loo and Annunziata (2016) evaluated WTP for conventional, organic and functional yoghurt products when either only key words (“plain”, “organic” and “functional”) or when additional product information is provided to consumers. For organic yoghurts, additional information included a claim about the methods of production. On functional yoghurts, additional product information included a function claim regarding the benefits of probiotics and vitamin B6 on immune function. The authors used an experimental auction design and a Tobit model to analyze the WTP of 100 Italian consumers in 2012. The results reveal that when only key words are provided (i.e.,, “functional” or “plain”), consumers were willing to pay 8% less for functional than plain yoghurts. When health claims and claims providing information about the method of production (e.g., claims about organic farming) are added to labels, consumers WTP for functional yoghurt increased by 36% and their WTP for organic yoghurt increased by 6%. In addition, the authors found that women were willing to pay more for organic and functional yoghurts than were men. Further, consumers that have children were willing to pay more for organic under the basic and additional information scenarios and were willing to pay more for functional yoghurt when additional information is present. Overall, the results suggest that health claims are an important tool for guiding dietary choices and increasing the value consumers place on functional foods.

Hwang, Lee, and Lin (2016) evaluated the impacts of health claims on overall product evaluations, WTP, and purchase intentions of fiber-enriched ice cream. The authors surveyed 108 U.S. students on their perceptions of regular and fiber-enriched ice-creams. The products contained one of three labeling conditions: labels that included only product information (“vanilla ice cream”), a nutrient content claim (“fiber-enriched”), and both a nutrient content claim and a health claim (“fiber-enriched” and “promotes digestive health"). The responses were evaluated with ANOVA and simple linear regression analysis. The results indicate that health claims and nutrient content claims significantly increased overall product evaluations and perceptions of the product's healthiness. Products that included labels with both a health claim and nutrient content claim were perceived as healthier than ice cream that had only a nutrient content claim. The use of labeling translated into increased purchase intentions, and, compared to regular ice cream, consumers were willing to pay $0.31 more for ice cream that contained a nutrient content claim and $0.52 more for ice cream that contained both types of claims.

Additionally, Markosyan, McCluskey, and Wahl (2009) evaluated consumers' attitudes towards functional foods and willingness-to-pay (WTP) for antioxidant enriched apples, which might help reduce the risk of cancer by protecting cells from free radicals. The authors surveyed 730 U.S. participants in 2006 and used a contingent valuation method and random utility model to estimate WTP for antioxidant enriched apples. WTP estimations indicated that consumers will pay a small premium between 6.4% to 9.4% for antioxidant enriched apples. When claims about the benefits of antioxidants were included, the premium for antioxidant enriched apples increased to between 7.4% and 12.1%. The results showed that consumers generally have a positive attitude towards functional foods. However, when examining the specific category of antioxidant enriched apples, some consumers remain skeptical and are more likely to reject the food due to a perceived riskiness associated with novel technologies. The results show the importance of developing health claim policy that educates consumers and provides a source of credible information for consumers.

Additionally, the type of health benefits and the personal relevance of the health attributes offered by functional foods affects the premium consumers are willing to pay

(Teratanavat and Hooker 2006). Teratanavat and Hooker (2006) investigated consumer attributes associated with WTP for regular tomato juice, tomato juice enriched with soy that had either a single health benefit or multiple health benefits, and tomato juice that was organic. Tomato juice that contains soy is high in lycopene and isoflavones and has the potential to decrease the risk of several diseases including heart disease and prostate cancer. The authors analyzed survey data from 1704 U.S. households using conditional and mixed logit models. The results indicated that, on average, consumers were willing to pay a premium of $0.93 for a single health benefit, $0.28 for multiple health benefits, and $0.41 for naturalness. Comparing females to males showed that, on average, males were willing to pay a premium of $0.40-$0.70 for these attributes whereas females were willing to pay between $0.35-$1.03. In addition, younger respondents were willing to pay larger premiums for single health benefits ($0.84-$1.14), multiple health benefits ($0.40-$0.54) and organic ($0.03-$0.07) than were older respondents. Older respondents were willing to pay larger premiums for naturalness ($0.64). These results indicate that consumers are not homogenous in their WTP for various product attributes of functional foods but there might be similarities within segments of the population. Therefore, marketing targeted at specific groups might be a more profitable approach for producers.

While health claims are found to increase WTP for functional foods, trust in food production methods also is important as some consumers remain skeptical of new and unfamiliar technologies used to produce functional foods (Barreiro-Hurle, Colombo, and Cantos-Villar 2008; Markosyan, McCluskey, and Wahl 2009). Barreiro-Hurle, Colombo, and Cantos-Villar (2008) evaluated the factors that contribute to WTP and acceptance of resveratrol-enriched wine and evaluate heterogeneity in consumer preferences. Resveratrol is a naturally occurring compound found in grapes that has antioxidant properties and might reduce the risk of certain illnesses. The authors use a choice experiment design to evaluate the responses from 296 Spanish participants. WTP is evaluated using a random parameter logit model. The results show that trust in the technologies used to produce functional wines and level of health concern increases acceptance and WTP for resveratrol-enriched wine. The only socio-economic factor that impacted product choice was education. Higher levels of education increased the likelihood of choosing a functional wine option over conventional options. Overall, consumers indicated a WTP premium of 55% (5.89 Euros) per bottle compared to conventional wines, suggesting future market potential for such products.

Additionally, Markosyan, McCluskey, and Wahl (2009) evaluate consumers' attitudes towards functional foods and willingness-to-pay (WTP) for antioxidant enriched apples, which might help reduce the risk of cancer by protecting cells from free radicals. The authors surveyed 730 U.S. participants in 2006 and used a contingent valuation method and random utility model to estimate WTP for antioxidant enriched apples. WTP estimations indicate that consumers will pay a small premium between 6.4% to 9.4% for antioxidant enriched apples. When claims about the benefits of antioxidants were included, the premium for antioxidant enriched apples increased to between 7.4% and 12.1%. The results showed that consumers generally have a positive attitude towards functional foods. However, when examining the specific category of antioxidant enriched apples, some consumers remain skeptical and are more likely to reject the food due to a perceived riskiness associated with novel technologies. The results showed the importance of developing health claim policies that educate consumers and provide a source of credible information for consumers.

3.2 The Demand for Food

Advertising is an important method of communicating valuable product information to consumers. Several papers have revealed that delivering product information through advertising can have significant impacts on the demand for foods (e.g., Goddard and Amuah 1989; Brester and Schroeder 1995; Zheng and Kaiser 2009). Goddard and Amuah (1989) evaluated the impacts of generic advertising (i.e., industry specific rather than brand specific) on the demand for fats and oils in Canada. The authors estimated a log-linear translog demand system using iterative seemingly unrelated regression (SUR) analysis on quarterly data from 1973 to 1986. The authors also estimated other functional form specifications (linear, log-log, and equations not directly derived from a specific utility function) but, ultimately, chose a log-linear functional form because it provided the most satisfactory results. Advertising expenditures were incorporated as a separate variable to capture the impacts of generic advertising of each commodity on demand for fats and oils. The elasticity estimates showed that own-advertising positively affected butter (0.005), margarine (0.04), shortening (0.03), and oils (0.07)[14]. In addition, butter advertising negatively affected margarine (0.01) demand and vice versa (0.06). Further, a 1% increase in oil advertising was expected to decrease margarine consumption by 0.05%. Overall, the results suggest positive returns to advertising in the Canadian fats and oils industry.

Brester and Schroeder (1995) evaluated the effects of generic advertising and brand advertising (i.e., product-specific) advertising on the demand for pork, poultry, and beef in the U.S from 1970 to 1993. The authors estimated an absolute price Rotterdam model using

[14] The American Journal of Agricultural Economics published an erratum in 1991 with corrections to the original estimated advertising elasticities. The corrected advertising elasticities from the 1991 erratum are discussed here.

SUR analysis on quarterly data. The advertising variable was captured by generic and branded advertising expenditures and was included as price and expenditure scaling factors and a demand shifter. Overall, the elasticity estimates showed that own-prices have the largest impacts on the demand for beef (-0.56), pork (-0.69), and poultry (-0.33). In addition, a 1% increase in brand advertising expenditures for beef was expected to increase beef consumption by 0.007%. For pork, a 1% increase in brand advertising expenditures was expected to increase pork consumption by 0.033%. Last, a 1% increase in branded advertising expenditures for poultry was expected to increase poultry consumption by 0.047%. Although the brand advertising elasticities are small, the authors point out that in large-volume product markets such in the meats industry, small elasticities can result in considerable aggregate effects. In contrast to branded advertising, generic advertising that took place for the beef and pork industries during the period did not have significant effects on demand.

In addition, Zheng and Kaiser (2009) examined the impacts of generic advertising and non-advertising marketing activities (e.g., sales promotions, retail services, and sponsorships) on the demand for fluid milk in the U.S. Quarterly time series data from 1986 to 2005 were used to estimate a double-log form of retail demand for milk in New York State, which was the third largest producer of milk during the time of the study. Generic and non-advertising marketing expenditures were included in the model as separate variables that were functions of the lag of expenditures to capture possible carryover effects. The results showed that generic advertising and non-advertising marketing activities for milk had a positive impact on milk demand. The short-term elasticities of generic advertising and non-advertising marketing activities were 0.014 and 0.0026, respectively, and the long-term elasticities were 0.038 and 0.007, respectively. In both the short-term and the long-term, advertising was a much more effective strategy for changing consumption patterns than non-advertising marketing activities, which might be due to the direct nature of its influence on consumers.

In addition to the impacts of generic and brand advertising, the effects of health information obtained from non-advertising sources, such as newspaper and journal articles, on the demand for foods has been found to have significant implications on consumer purchasing behavior (Brown and Schrader 1990; Capps and Schmitz 1991; Nichele 2003; Adhikari et al. 2006; Adhikari et al. 2007; Tonsor, Mintert and Schroeder 2010). Brown and Schrader (1990) examined how increasing awareness since the 1960s about the link between dietary cholesterol and an increased risk of CVD affected the demand for food, specifically shell egg consumption in the U.S. Fixed and variable coefficient demand models were estimated using fixed weighted 2SLS and quarterly price and domestic disappearance data from 1955 to 1987. The authors developed a cholesterol information index based on the number of journal articles about the link between dietary cholesterol and heart disease that were published per quarter over the period. Articles supporting the link added one unit to the total and articles opposing the link resulted in a one unit subtraction from the total. The cholesterol information index was used as a proxy for consumer knowledge about the health effects of cholesterol. Overall, cholesterol information had negative effects on the demand for eggs. By 1987, cholesterol information was estimated to have decreased shell egg consumption by approximately 16%. However, the magnitude of the negative effect fell after 1983 implying that the strength of the effects of additional health information on purchasing behaviors might decline once knowledge of a relationship is well-established.

In a similar study, Capps and Schmitz (1991) studied how increases in published, scientific literature about dietary cholesterol altered the demand for pork, poultry, beef and fish in the U.S over the period 1966 to 1988. The authors used a modified Rotterdam model that includes Brown and Schrader's (1990) cholesterol information index. The model used annual price and quantity data and was estimated using an iterative Zellner estimation procedure to ensure consistency and asymptotic normality of the estimated coefficients. The results showed that own-prices had the largest impacts on pork (-0.1271), poultry (-0.0504), beef (-0.1458) and fish (-0.0224) consumption. However, the cholesterol information index also had statistically significant, but relatively small effects on the demand for pork (-0.0009), poultry (0.0009) and fish (0.0002). Although the estimated effects were small, the statistical significance emphasizes the importance of expanding traditional demand analysis to include the influence of health and nutrition information on consumption patterns.

Nichele (2003) found similar, but larger, effects of health information regarding dietary fats and cholesterol on the demand for foods in France. The author estimated a quadratic AIDS (QUAIDS) model for 15 food groups to understand how consumers altered their consumption when new health information was made available. The author used household expenditure and quantity survey data obtained from approximately 6750 households over the period 1978 to 1991. A cholesterol information index, which accounts for the number of related published journal articles over the sample period, was incorporated as a demand shifter by modifying the intercept to include the addition of the cholesterol information variable. In general, the results showed that fat and cholesterol information created a shift away from foods higher in saturated ("bad") fats, such as butter, beef, eggs, and pork, towards foods higher in polyunsaturated ("good") fats and lower in saturated fats, such as oils. The results showed that increases in information about the negative health effects associated with fat and cholesterol consumption negatively affected the demand for beef (-0.30), eggs (-0.33), butter (-0.22), pork (-0.16), and, surprisingly, vegetables (-0.11). In contrast, increases in cholesterol information had positive impacts on the demand for yoghurt (0.72), milk (1.03), oils (0.28), and grains (0.18). This study highlights the potential significant impacts of diet-health information on the demand for foods.

Adhikari et al. (2006) examined the simultaneous impacts of cholesterol awareness on U.S. meat demand when there was also growing interest in low-carbohydrate diets. Using quarterly data from 1989 to 2003, the authors estimated a linear approximate AIDS (LA/AIDS) model for beef, pork, poultry, and fish in the U.S. using SUR analysis. An up-to-date version of Brown and Schrader's (1990) health information index, which involves accounting for the number of related published journal articles over the sample period, was used as a proxy for awareness about the impacts of cholesterol on health. The authors used Pollak and Wales (1980) translation procedure to incorporate the cholesterol information index variable as a demand shifter by adding it to the intercept term. To capture the impacts of the changing awareness of low-carb diets that occurred after 1997, the dataset was evaluated in two sample periods: (1) 1989 to 2003 and (2) 1997 to 2003. The elasticity estimates showed that cholesterol information had statistically significant negative impacts on the demand for pork (-0.05), but positive impacts on the demand for poultry (0.07). When information about low-carbohydrate diets was considered (by evaluating differences in elasticity estimates between the two sample periods), the elasticity estimates decreased in absolute magnitude by 0.04 for pork and 0.04 for poultry. The results suggest that opposing information about low-carb diets can lessen the impacts of negative cholesterol information.

In a similar study, Adhikari et al. (2007) evaluated how awareness about the impacts of low-carbohydrate diets on health altered the demand for vegetables in the U.S. Low-carbohydrate diets became popular due to the weight-loss benefits and the growing rate of obesity in the U.S. The authors used a LA/AIDS framework and SUR analysis to estimate the demand for tomatoes, broccoli, lettuce, mushrooms, and potatoes using annual data from 1980 to 2003. A low-carb diet information index was created based on the number of related published journal articles over the period and was used to capture awareness about low-carb diets. The low-carb diet index was included as a separate regressor. The low-carb information index elasticities revealed that the demand for tomatoes (0.06) and lettuce (0.07) were positively affected by information about low-carb diets, while the demand for potatoes (-0.09), broccoli (-0.26), and mushrooms (-0.17) were negatively affected. Own-price elasticity estimates for tomatoes (-0.40), lettuce (-0.61), broccoli (-0.33), mushrooms (-0.79), and potatoes (-0.33) reveal that own-prices have much larger impacts on the demand for vegetables than emerging health information. Nonetheless, the results indicate that consumers do incorporate health information and dietary trends into their consumption patterns.

Additionally, Tonsor, Mintert and Schroeder (2010) evaluated the impacts of health information about 1) fat, cholesterol and heart disease; 2) zinc, protein and iron; and 3) low carbohydrate diets on the demand for meats in the U.S. from 1982 to 2007. Fat and cholesterol have been linked to heart disease and are higher in pork and beef than in poultry (Nichele 2003). Iron and zinc are minerals that are essential for the maintenance of good health (Livestrong 2014). Beef, and pork to a lesser extent, are high in both iron (Dieticians of Canada 2016) and zinc (Dieticians of Canada 2017). Research indicated positive benefits of low-carb diets (or high protein diets) on health until around 2003, after which research about the health impacts of low-carb diets was largely negative (Tonsor, Mintert and Schroeder 2010). To analyze the effects of these three health issues, Tonsor, Mintert and Schroeder (2010) estimated an absolute-price Rotterdam model with quarterly data from 1982 to 2007. A health information index was constructed for each of the three health issues as a proxy for related consumer awareness. The information indices were constructed based on the number of related published journal and newspaper articles over the sample period. The authors used an iterative three-stage least squares to estimate demand equations for pork, beef, poultry, other foods and non-foods. Lagged health information indices were statistically insignificant, indicating that the effects of new health information on demand deteriorate quickly and have larger impacts on consumption patterns in current periods. Elasticity estimates indicate that fat, cholesterol and heart disease information decreased beef demand (-0.0226), zinc, protein and iron information increased beef demand (0.0248) and poultry demand (0.0482), and low-carb diet information increased beef demand (0.0077). The study again shows the importance of emerging health trends in the demand for meat in the U.S.

Research has also shown that generic advertising can lessen the effects of adverse health information obtained from non-advertising sources (e.g., publications and media) on the demand for foods (e.g., Chang and Kinnucan 1991; Boetel and Lui 2003). Chang and Kinnucan (1991) examined the simultaneous impacts of generic advertising and health information (non-advertising) about cholesterol and saturated fat on the demand for butter, margarine, shortening and salad oils in Canada from 1974 to 1985. Over the sample period, producer check-off programs for the dairy industry were used to fund generic advertising campaigns. The authors used SUR analysis and quarterly data to estimate a semi-log model of demand. Like Brown and Schrader (1990), a cholesterol information index was used as a proxy for consumer awareness of the negative effects of cholesterol and fats on health. The cholesterol index was included as a separate regressor whereas advertising expenditures augment the price variables. The elasticity estimates reveal that advertising had positive effects on butter demand (0.02), but adverse cholesterol information negatively affected butter demand (-0.29). Cholesterol information also had positive impacts on the demand for oils (0.04). The authors also did simulation experiments that held the cholesterol index constant at the lowest observed value while changing advertising expenditures to the highest observed values (and vice versa) to determine the effects on butter demand. The results revealed that increases in adverse cholesterol information would decrease the demand for butter by 24.4% whereas increases in advertising that provided positive information would increase butter consumption only by 5.6%.

In a similar study, Boetel and Lui (2003) examined the simultaneous effects of generic advertising and health information related to fat and cholesterol obtained from non-advertising sources (i.e., published articles and media) on the demand for meat in the United States. A LA/AIDS model for beef, pork, poultry and fish was estimated using U.S. quarterly data on quantities and prices from 1976 to 2000. A food health information index that considers the number of related published journal articles over the sample period was used to capture consumer awareness of fat and cholesterol. The results indicated that increases in fat and cholesterol concern from non-advertising sources since 1987 significantly affected the demand for meat in the U.S. Specifically, the authors found a 6.32% decrease in beef consumption per capita per quarter, an 18% increase in poultry consumption per capita per quarter, and a 2% increase in pork consumption per capita per quarter. This suggests that consumers incorporate information about diet-health relationships into their purchasing decisions and change the distribution of their expenditures accordingly.

The literature has revealed that the use of product labels to convey health and food safety information can significantly alter the demand for food (e.g., Mathios 2000; Tiesl, Bockstael and Levy 2001; Dedah, Keithly, Jr., and Kazmierczak 2011). In that regard, Mathios (2000) investigated how the legislation of mandatory NFT labeling after the introduction of the NLEA affected the demand for salad dressings with different total fat contents in the U.S. The author examined the "ex-post" impacts of the NLEA using retail scanner data obtained from 50 U.S. supermarkets from 1992 to 1995. Retail scanner data records the weekly prices and volumes of goods sold at grocery stores using point-of-sale systems. The supermarkets also provided consumer demographic information collected from surveys. The author used descriptive statistics and a differentiated product demand model based on the McFadden conditional logit model. Prior to the introduction of the NLEA in 1994, salad dressings without NFT labeling constituted 73% of the market share in supermarkets located in the lowest educated regions. In comparison, unlabeled salad dressings had 46% of the market share in supermarkets located in the highest educated regions. Post-NLEA, the market share of previously unlabeled salad dressings fell between 2.2% and 3.1% depending on the regions level of education. The products with the highest total fat content experienced the largest drops in market share once nutrition labels were required. These findings provide evidence that consumers are receptive to information provided on nutrition labels, which can lead to changes in purchasing behaviour. Mandatory labeling policies could have significant impacts on consumption patterns and public health outcomes.

Similarly, Tiesl, Bockstael and Levy (2001) evaluated the demand and welfare effects of advertising nutritional information on shelf tags in grocery stores as well as using in-store nutritional education campaigns. The researchers used monthly retail scanner data from 1986 to 1989 obtained from 25 grocery stores in the U.S. Twelve stores served as a control group and did not implement any labeling or education programs. The other 13 stores provided labels on shelves ('shelf tags') that indicated milk, cream cheese, peanut butter, refried beans, mayonnaise and salad dressings options that were low or reduced in fat, cholesterol, and/or sodium compared to conventional versions. Products were considered "healthy" if they qualified for a low/reduced shelf label and "unhealthy" if they did not. An AIDS model was used to estimate a demand system for each of the products and a value-of-information (VOI) approach was used to estimate the welfare changes from the labeling program. The results revealed that the labeling program increased the demand for healthy versions of milk by 13%, cream cheese by 9%, and refried beans by 50%. In contrast, the labeling policy decreased the demand for healthy versions of mayo by 14% and salad dressings by 9%, although these negative effects diminished over time. The authors suggest the nutrition labels for healthy options of mayonnaise and salad dressings (e.g., 'low fat') might have been viewed by some consumers as a sign of reduction in flavor thus creating an initial decrease in demand for the healthy options. In addition, the authors found that labelling provided statistically significant social benefits of $6.3 billion for milk, $4.8 billion for peanut butter, $2.3 billion for salad dressing, and $1.4 billion for mayonnaise. Overall, the results suggest that labelling policies can have significant impacts on demand and consumer welfare.

Dedah, Keithly, Jr., and Kazmierczak (2011) evaluated how a labeling policy and media attention indicating health risks associated with consuming Gulf oysters during the 1990s affected the demand for Gulf oysters and its substitutes: Chesapeake, Pacific, and imported oysters. During the 1990s, the U.S. introduced mandatory warning labels on raw oysters from the Gulf region due to their potential for carrying a potentially life threatening *Vibrio vulnificus* bacterium. To evaluate the impacts of the mandatory labeling policy, the authors estimated an inverse AIDS (IAIDS) using iterative SUR (ITSUR) analysis and quarterly retail scanner data from 1985(1) to 2008(4). To capture changes in demand evolving over time due to the labeling and media exposure, the label and media variable took the value zero before the *Vibrio* event and then follows an exponential cumulative distribution function (CDF) for two years before taking the value of one for the remainder of the sample period. The results showed that the warning labels and media attention of the *Vibrio* event caused the market share of Gulf oysters to fall from 67% to 54%. In addition, the market share for Chesapeake oysters, which carry the same oyster species as the Gulf region but were not affected by the *Vibrio* event, fell from 11% to 7%. The authors suggest the spillover might due to imperfect information and consumers' failure to accurately discern product source. The labeling policy and media coverage also was found to cause consumers to substitute away from Gulf and Chesapeake oysters towards Pacific and imported oysters. The market share for Pacific oysters rose by approximately 60% and the market share for imported oysters nearly doubled. The authors suggest that government intervention could help reduce the negative spillover effects by providing consumers with more accurate information that can be easily understood and implemented by target groups.

3.3 Population Health Studies

The literature on population health status has revealed that socio-economic factors, such as income, education, and healthcare resources, can have positive impacts on population health status across countries (e.g., Filmer and Pritchett 1999; Or 2001; Thornton 2002;

Berger and Messer 2002). Filmer and Pritchett (1999) examined the impacts of public health spending and income on child mortality rates across 100 countries from Asia, Africa, Latin America and the Caribbean. Data from 1987 to 1995 were obtained from UNICEF and the World Bank databases. The authors estimated a log-linear health production function using ordinary least square (OLS), median regression and two-stage least squares (2SLS). The authors question education and income as a potential source of reverse causation bias. However, the results from the 2SLS and OLS regressions were very similar and the authors suggest that reverse causation bias might not an issue when evaluating health status at the aggregate level. As a proxy for health status, the authors used child mortality rates as the dependent variable. The results showed that a 1% increase in income was expected to decrease child mortality rates by 0.60%. As for education, an additional year of female education was expected to decrease child mortality rates by 10%. In addition, a 1% increase in public health spending could be expected to decrease child mortality rates between 0.073% to 0.192%.

Additionally, Or (2001) found that income and healthcare resources have large positive impacts on population health status. The author used feasible generalized least squares (FGLS) to estimate a log-linear health production function for 21 OECD countries from 1970 to 1995. Data were obtained from the OECD Health Database. Both life expectancy and mortality rates were used as proxies for population health status in different specifications. The results revealed that a 10% increase in income was associated with a 4.8% decline in infant mortality rates and an increase in female and male life expectancy at age 65 of approximately 1%. In addition, the availability of doctors and public healthcare expenditures are used in separate specifications as proxies for healthcare resources. The results show that a 10% increase in the availability of doctors led to a decrease in infant mortality rates of 6.5% and increase male and female life expectancy at age 65 of about 1%. In contrast, a 10% increase in public healthcare expenditures is found to decrease infant mortality rates by 2.3%, but did not have statistically significant impacts on life expectancy at age 65. The author also found that lifestyle and environmental factors had statistically significant implications on health outcomes. For example, a 10% increase in alcohol consumption was expected to decrease life expectancy at age 65 by approximately 0.2% for males and 0.1% for females. Similarly, a 10% increase in tobacco consumption was expected to decrease life expectancy at age 65 by 0.3% for males and 0.2% for females. Last, a 10% increase in NO_x emissions was expected to decrease male life expectancy at age 65 by 0.1%.

Similarly, Thornton (2002) also found that income, education and healthcare resources positively affects health status in the U.S. The author used U.S. state level data from 1996 to 2007 and 2SLS to estimate a log-linear health production function. Health status of the U.S. population was captured by the age-adjusted death rate. The results indicated that, all else equal, a 1% increase in income could be expected to decrease death rates by 0.20%. Additionally, a 1% increase in the proportion of the population with at least upper secondary education was expected to decrease death rates by 0.179%. As for healthcare resources, a 1% increase in medical care expenditures is found to decrease death rates by 0.065%. Elasticity estimates also showed that increases in the consumption of alcohol (0.038) and tobacco (0.077) would be expected to increase death rates in the U.S. The author concluded that more focus should be placed on the importance of lifestyle factors than medical care expenditures. In addition, population health and social welfare could benefit greatly from policies that place a greater emphasis on access to education.

Berger and Messer (2002) also found that income and education had significant impacts on health. The authors estimated a double log health production function for 20 OECD countries using data from the OECD Health Database. The models were estimated using country and year fixed effects to control for unobserved differences across countries and time. Mortality rates per 1000 population were used as a proxy for health status. The elasticity estimates revealed that, all else equal, a 1% increase in GDP per capita would be expected to reduce mortality rates by 0.0271%. Similarly, a 1% increase in the number of people with at least upper secondary education would be expected to decrease mortality rates by 0.0166%. In addition, the author found that lifestyle factors also had significant implications on health outcomes. Elasticity estimates revealed that the consumption of animal fats (0.0126), alcohol (0.0477), and tobacco (0.1231) increased mortality rates in OECD countries.

In contrast to the above studies, healthcare resources also have been found to negatively affect health outcomes. Fayissa and Gutema (2005) estimate the socioeconomic and lifestyle factors that contribute to health status in Sub-Saharan Africa (SSA) from 1990 to 2000. The authors obtained data on 31 SSA countries from the World Bank and estimated a two-way random effects regression model using generalized least squares (GLS). Life expectancy at birth was used as a proxy for health status in SSA. The results show that a 1% increase in healthcare expenditures would be expected to decrease life expectancy at birth by 0.096% in SSA. The authors suggested that the negative impacts of healthcare on life expectancy at birth is due to inefficiencies in the system that result in the costs of providing healthcare resources outweighing the benefits to society. In contrast to healthcare resources, the authors found that a 1% increase in income was expected to increase life expectancy at birth by 0.05%. In addition, the authors found that a 1% increase in food availability per capita would be expected to increase life expectancy at birth by 0.14%. The findings suggest that health policy should not only include the delivery of healthcare resources, but also facilitate improvements in other socio-economic factors, such as income and food availability.

In addition to socioeconomic factors such as income, education and healthcare, lifestyle factors, such as diet and alcohol and tobacco consumption, are also recognized to as significant determinants of population health outcomes (e.g., Cremieux, Ouellette, and Pilon 1999; Miller and Frech 2000; Shaw, Horrace and Vogel 2005). Cremieux, Ouellette, and Pilon (1999) examined the relationship between health outcomes and socioeconomic and lifestyle factors in Canada over the period 1978 to 1992. GLS was used to estimate a fixed effect model that controls for time invariant differences across provinces. Life expectancy at birth and infant mortality rates were used as proxies for health status. As a proxy for diet, total weekly expenditures on meat and fat were used. The results showed that a 1% increase in meat expenditures would be expected to decrease female life expectancy at birth by 0.013% and decrease male infant mortality rates by 0.117%. Also, a 1% increase in spending on fats would be expected to increase female infant mortality rates by 0.201%, increase male infant mortality rates by 0.242% and decrease male life expectancy by 0.005%. Further, elasticity estimates revealed that alcohol consumption could decrease female (-0.008) and male (-0.020) life expectancy at birth. Tobacco consumption also negatively affects female (-0.002) and male (-0.018) life expectancy at birth. Additionally, elasticity estimates indicated that income per capita positively affects male (0.010) and female (0.018) life expectancy at birth as do the number of physicians (elasticity estimates of 0.026 and 0.028 for male and female life expectancy at birth, respectively). The results showed that both lifestyle and socioeconomic factors are significant determinants of health in Canada.

Additionally, Miller and Frech (2000) found significant impacts of diet, tobacco, and alcohol consumption on population health. The authors examined the returns from pharmaceutical consumption, lifestyle factors and socioeconomic factors on health outcomes in 21 OECD countries using data from the 1996 OECD Health Database. A double-log functional form was used to estimate a health production function. Life expectancy at birth, age 40, and age 60 were used as proxies for health status. The consumption of calories from animal fat was used as a proxy for diet. A squared term for animal fat consumption was also included to capture a non-linear effect of animal fat consumption on health. The results showed that at low levels, increases in animal fat consumption had positive effects on all measures of life expectancy (coefficient on non-squared terms of 1.4040 for life expectancy at birth, 0.9548 for life expectancy at age 40, and 0.9096 for life expectancy at age 60). However, a negative sign on the squared terms for animal fat consumption indicated that after a certain point, increases in the consumption of animal fat decreases all measures of life expectancy (coefficient on squared terms of -0.1045 for life expectancy at birth, -0.0728 for life expectancy at age 40, and -0.0706 for life expectancy at age 60). In addition, doubling alcohol consumption is expected to decrease life expectancy at birth by approximately 1.5%. The results also showed that a 1% increase in pharmaceutical expenditures is expected to increase life expectancy at ages 40 by 2% and life expectancy at age 60 by 4%.

Shaw, Horrace and Vogel (2005) evaluated the impacts of diet, lifestyle and socioeconomic factors on health outcomes in OECD countries. The authors estimated a health production function for 19 OECD countries from 1960 to 1999. A log-linear functional form with country random effects was estimated using residual maximum likelihood estimation. The authors used life expectancy as a proxy for health status. The elasticity estimates revealed that tobacco consumption had statistically significant negative effects on population life expectancy at age 40 (-0.067) and, surprisingly, butter consumption, which has higher saturated fat content (American Heart Association 2017a), had positive effects on population life expectancy at age 40 (0.022). In addition, elasticity estimates revealed that fruit and vegetable consumption positively affects female life expectancy at age 40 (0.081) and male life expectancy at age 40 (0.140). The authors also calculated how consumption factors would need to change to change life expectancy by one year. Their results suggest that to increase life expectancy by one year for 40-year old females, tobacco consumption must fall by 976 g/year, fruit and vegetable consumption must increase by 55 kg/year.

In addition to diet, tobacco, and alcohol, the level of environmental quality has been found to significantly affect health outcomes (e.g., Joumard et al. 2008). Joumard et al. (2008) estimated a health production function for 23 OECD countries using data from 1981 to 2003. The authors used GLS with country fixed effects to estimate the health production function. The authors used both measures of life expectancy and mortality rates as a proxy for health status and found minimal variation between the two. Consumption of fruits and vegetables was used as a proxy for diet and per capita emissions of nitrogen oxide (NO_x) were used as a proxy for environmental quality. NO_x can play a role in fine particulate matter formation and smog, both of which can cause serious health issues. The results of the study showed that a 1% increase in NO_x emissions could be expected to decrease male life expectancy by 0.065% and female life expectancy by 0.037%. In addition, a 1% increase in tobacco consumption was found to decrease female life expectancy at age 65 by 0.019% and male life expectancy at age 65 by 0.057%. Diet also was found to improve female and male life expectancy at age 65, but more so for males than females (elasticity estimates of 0.013 and 0.028 for females and males, respectively). In addition, elasticity estimates indicate income, education, and health spending positively affect female life expectancy at age 65 (0.044, 0.064, and 0.051, respectively) and male life expectancy at age 65 (0.107, 0.045, and 0.061, respectively).

3.4 Summary of Literature Review

This chapter examined three types of literature related to this thesis: (1) consumer acceptance and willingness-to-pay for functional foods; (2) the demand for foods; and (3) the determinants of population health status. The literature on functional foods focused on the "*ex-ante*" factors contributing to acceptance and WTP for functional foods using surveys, interviews, and hypothetical product scenarios. The results from the relevant functional foods literature revealed that one of the most important factors contributing to consumer acceptance of functional foods is belief and credibility in the health benefits of consuming functional foods (Urala and Lähteenmäki 2004; Verbeke 2005; van Kleef, van Trijp, and Luning 2005). Further, the use of health claims can significantly improve acceptance of functional foods, product evaluations, and product choice (van Kleef, van Trijp, and Luning 2005; van Trijp and van der Lans 2007; Chrysochou and Grunert 2014; Huang and Lu 2016). However, the type of claim used and the specific health benefit can affect consumer understanding and attitudes towards health claims (Kleef, van Trijp, and Luning 2005; van Trijp and van der Lans 2007).

Further, the presence of health claims on front-of-package (FOP) labels and extent at which consumers make use of additional product information affects acceptance, product evaluations and purchase intentions for functional foods (Roe, Levy, and Derby 1999;

Goodman et al. 2012). When claims are present on FOP labels, consumers are more likely to purchase products (Roe, Levy, and Derby 1999; Goodman et al. 2012), to limit the search for additional information (Roe, Levy, and Derby 1999), and to make healthier choices (Goodman et al. 2012). In addition, the personal relevance and familiarity with the claimed health benefits can increase acceptance and purchase intentions (Peng et al. 2006; Ding, Veeman and Adamowicz 2015).

Regardless of belief in the health benefits and the presence of health claims, researchers have found that the appeal of improved health might not be enough to convince consumers to sacrifice flavor, smell, and texture for added health benefits in foods (e.g., Verbeke 2006; Hoppert et al. 2013; Yi et al. 2014; Miklavec et al 2015). In addition, acceptance has been found to be dependent upon whether consumers perceive the healthy ingredient (e.g., fiber, omega-3s or vitamins) and its carrier food (e.g., granola bars or yoghurt) to be a good combination together (Krutulyte et al. 2011; Lu 2015).

As for willingness-to-pay for functional foods, "*ex-ante*" studies have shown that credibility and belief in the health benefits offered by functional foods can significantly increase consumer WTP for functional foods (Maynard and Franklin 2003; MarketLine 2012, 2014). Research indicated consumers are WTP between $0.15 to $0.41/gal more for CLA enriched dairy products compared to conventional versions dependent upon the health benefits of CLA being supported by the medical community (Maynard and Franklin 2003). In addition to belief, the use of health claims can increase WTP for functional foods (Van Wezemael et al. 2014; Vecchio, Van Loo and Annunziata 2016; Hwang, Lee, and Lin 2016). Consumers' WTP for functional yoghurt increased by 36% when claims were present on labels (Vecchio, Van Loo and Annunziata 2016). Further, WTP differs across consumers, claim types, and genders. Consumers in France (EUR 6.73/kg), Holland

(5.78/kg) and Belgium (5.60/kg) expressed the greatest WTP for claims about saturated fats compared to other nutrients (Van Wezemael et al. 2014) and women were found to be willing to pay more for functional yoghurts than were men (Vecchio, Van Loo and Annunziata 2016).

The demand for foods literature has indicated that generic and brand advertising (Goddard and Amuah 1989; Brester and Schroeder 1995; Zheng and Kaiser 2009), health information (non-advertising sources) (Brown and Schrader 1990; Capps and Schmitz 1991; Nichele 2003; Adhikari et al. 2006; Adhikari et al. 2007; Tonsor, Mintert and Schroeder 2010), and certain types of labelling policies (Mathios 2000; Tiesl, Bockstael and Levy 2001; Dedah, Keithly, Jr., and Kazmierczak 2011) can significantly affect demand. Results from the literature show that consumer demand increases in response to advertising (e.g., Goddard and Amuah 1989; Brester and Schroeder 1995; Zheng and Kaiser 2009; Chang and Kinnucan 1991; Boetel and Lui 2003). Specifically, a 1% increase in own-advertising expenditures has been shown to increase the demand for fats and oils between 0.005 to 0.07% (Goddard and Amuah 1989), the demand for meats between 0.007 to 0.047% (Brester and Schroeder 1995), and the demand for dairy between 0.0026 to 0.014% (Zheng and Kaiser 2009).

Further, the demand literature indicates that consumers adjust their dietary patterns in response to awareness of health information obtained from non-advertising sources. A health information index that accounts for the number of related published journal articles over the period is typically used as a proxy for awareness of health information (e.g., Brown and Schrader 1990; Capps and Schmitz 1991; Nichele 2003; Adhikari et al. 2006; Adhikari et al. 2007; Chang and Kinnucan 1991; Boetel and Lui 2003; Tonsor, Mintert, and Schroeder 2010; Xiong, Sumner, and Matthews 2013). The literature indicates that a 1%

increase in available health information (non-advertising sources) regarding the negative health impacts of consuming saturated fats and cholesterol decreased the demand for foods higher in saturated fats (e.g., butter, pork, beef, eggs) between 0.0009% and 0.33% (e.g., Brown and Schrader 1990; Capps and Schmitz 1991; Chang and Kinnucan 1991; Nichele 2003; Boetel and Lui 2003; Adhikari et al. 2006; Tonsor, Mintert, and Schroeder 2010). In addition, a 1% increase in available health information about saturated fats and cholesterol increased the demand for foods lower in saturated fats (e.g., salad oils, poultry, and fish) between 0.002% and 0.28% (e.g., Capps and Schmitz 1991; Boetel and Lui 2003; Nichele 2003; Tonsor, Mintert and Schroeder 2010).

Additionally, elasticity estimates between 0.007 and 0.04 indicate consumers respond to information about the health benefits of low-carb diets (i.e., high protein diets) by increasing their consumption of pork, poultry, and beef (Adhikari et al. 2006; Tonsor, Mintert, and Schroeder 2010). Further, elasticity estimates indicate that information about the health benefits of consuming iron, zinc, and protein was found to increase the demand for beef (0.0248) and poultry (0.0482) (Tonsor, Mintert, and Schroeder 2010).

The demand literature has revealed that certain labelling policies can improve the demand for healthy foods (Mathios 2000; Tiesl, Bockstael and Levy 2001; Dedah, Keithly, Jr., and Kazmierczak 2011). Previous research on nutrition and health labelling policies has been focused in the U.S. using retail scanner data that records the prices and quantities of goods sold in grocery stores using point-of-sale systems. The literature indicated that the introduction of the mandatory NFT labelling policies in the U.S. reduced the market share of previously unlabeled salad dressings between 2.2 and 3.1% with high fat salad dressings having the largest decrease (Mathios 2000). Further, nutrient content claims provided on shelf tags in grocery stores was found to increase the demand for milk by 13%, cream cheese by 9%, and refried beans by 50% compared to conventional versions that did not have the nutrient content claims on shelf tags (Tiesl, Bockstael and Levy 2001). Labels that provided information about the health risks of consuming certain oysters decreased their market share by approximately 13% (Dedah, Keithly, Jr., and Kazmierczak 2011).

The literature on population health has revealed that several socioeconomic, lifestyle, and environmental factors contribute to health status. Specifically, income (e.g., Filmer and Pritchett 1999; Or 2001), education (e.g., Or 2001, Filmer and Pritchett 1999; Berger and Messer 2002) and healthcare resources (e.g., Or 2001; Filmer and Pritchett 1999; Thornton 2002) typically have positive impacts on health outcomes. As for diet, the consumption of fruits and vegetable also improves health status (e.g., Shaw, Horrace and Vogel 2005), but the impacts of fat consumption remain mixed (e.g., Cremieux, Ouellette, and Pilon 1999; Miller and Frech 2000; Shaw, Horrace and Vogel 2005). Tobacco and alcohol consumption has been found to decrease health status (e.g., Cremieux, Ouellette, and Pilon 1999; Miller and Frech 2000; Or 2001; Shaw, Horrace and Vogel 2005; Joumard et al. 2008). Environment, using pollution as a proxy, also was associated with a significant decrease in health outcomes (e.g., Or 2001; Joumard et al. 2008).

In general, the literature on acceptance of functional foods, the demand for foods, and population health indicated that consumers consider information from various sources when making dietary decisions and that diet has significant impacts on population health. However, the current literature has not specifically examined the impacts of information provided in health claims on the demand for foods or how health claim policy affects population health status. Hence, the contribution of this thesis will be to empirically evaluate the efficacy of current health claim policies in Canada and the U.S. at influencing demand and improving health outcomes.

CHAPTER 4

4. Theoretical Model

4.1 Graphical Analysis: Impacts of Health Claim Policy

Market failure in the functional food industry could occur due to imperfect information and healthcare externalities (Hobbs, Malla and Sogah 2014). Market failure occurs when the private market equilibrium does not equal the socially optimal equilibrium and there is a loss of welfare due to an inefficient use of resources (Watts and Segal 2009). In the absence of health claims on foods, there is imperfect information in the functional foods industry because consumers might not understand the implications of their dietary choices on their health or, due to the credence nature of functional foods, consumers might not recognize which foods provide extra health benefits (Veeman 2002; Henson, Herath and Cranfield 2006). As a result, they might under-consume healthy foods and over consume unhealthy foods. In addition, market failure in the functional foods industry could occur if consumers do not bear the full costs associated with poor dietary choices such as in a public healthcare system (e.g., Canada) or private health insurance system (e.g., U.S.) (Hobbs, Malla and Sogah 2014). In this case, consumers might lack an incentive to consume healthy or unhealthy foods at the socially optimal levels since they are not responsible for all the costs. Again, the private optimal consumption of healthy foods is below the socially optimal level because of the healthcare externality.

A graphical analysis of the impacts of health claim regulations in the functional foods industry is provided in Figure 1. The socially optimal equilibrium occurs where the marginal social benefit (MSB) of consuming functional foods equals the marginal social cost (MSC) of producing them. The social benefits include all private benefits, for example, improved health and well-being, plus external benefits to society such as reduced public healthcare costs. The social costs include all direct and indirect costs associated with producing functional foods, for example, the costs of labour and pollution. At the social equilibrium, P* and Q*, net social welfare from the consumption of functional foods is maximized.

In the absence of health claims, the marginal private benefit (MPB) of consuming functional foods is lower than the MSB. The initial private equilibrium occurs where MPB_1 is equal to the MSC and the private optimal price and quantity are at P_1 and Q_1. Health claims can assist the consumption of healthy foods by providing an incentive to consumers in the form of improved health and well-being. As a result, consumers place greater value on the consumption of functional foods, MPB_1 will shift to MPB_2, and the new private equilibrium occurs at P_2 and Q_2. However, since consumers do not bear the full costs of an unhealthy diet, MPB_1 does not shift all the way to MSB. Instead, the distance between MPB_2 and MSB represents the healthcare externality.

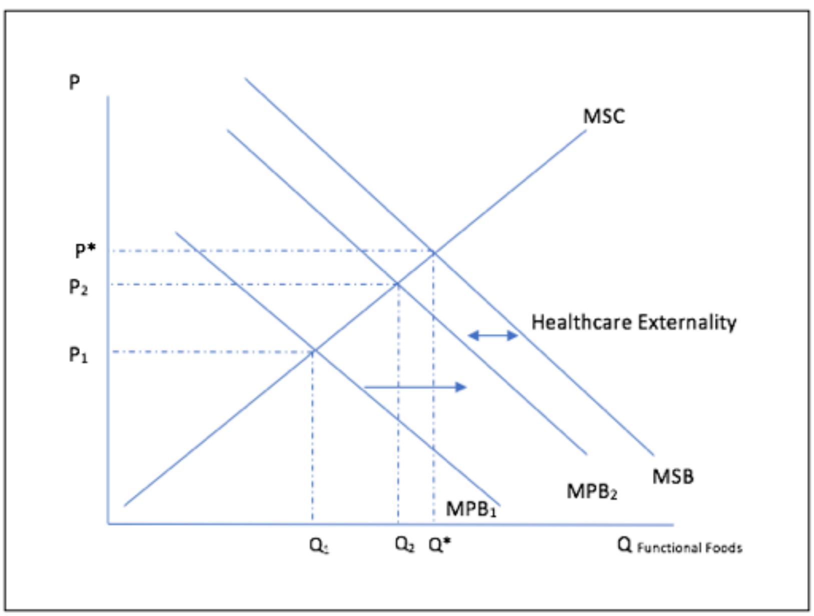

Figure 1. Impact of Health Claim Regulations on Consumption of Healthier Foods

Source: Author

To address the healthcare externality, the government could choose to intervene through the provision of a tax credit to consumers of functional foods. If the government provided an appropriate amount of a tax credit, then consumers would have additional benefit from the consumption of functional foods and the MPB_2 would shift right to align with the MSB. The new equilibrium consumption would occur at the socially optimal Q*.

It is expected that the regulation of health claims in Canada and the U.S. will benefit society by promoting the consumption of functional foods through the provision of credible health information. As the consumption of functional foods increases, it is also expected that social welfare in Canada and the U.S. will benefit from improved population health and a reduction in the economic burden of chronic disease.

4.2 Demand Analysis

4.2.1 Choice of Functional Form

The choice of functional form is very important for applied demand analysis as it can greatly influence the outcome of the elasticity estimates (Dameus et al. 2002). The most popular choices of models used in the analysis of food demand have been variations of both the Rotterdam model developed by Barten (1964) and Theil (1965) and the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbeaur (1980) (e.g., Capps and Schmitz 1991; Brester and Schroeder 1995; Boetel and Lui 2003; Rickertsen et al. 2003; Piggott and Marsh 2004; Adhikari et al. 2006; Tonsor, Mintert and Schroeder 2010). Other popular models have included the translog model developed by Christensen, Jorgenson and Lau (1975) as well as the generalized Leontif model.

The AIDS and Rotterdam models are similar in that they have flexible functional forms (Brester and Schroeder 1995; Barnett and Seck 2008) that depend on duality theory (Barnett and Seck 2008). Flexible functional forms are important to ensure that the functional form does not *a priori* restrict the elasticities of demand (Berndt, Darrough, and Diewert 1977). In addition, the AIDS and Rotterdam models allow theoretical restrictions, such as adding-up, symmetry and homogeneity, to be easily imposed (Adhikari et al. 2006; Barnett 2008) and modifications to the models can be made to incorporate sociodemographic variables and other demand shifters (Tonsor, Mintert and Schroeder 2010). Lastly, both models can be estimated in linear form which eases estimation and hypothesis testing (Boetel and Lui 2003; Barnett and Seck 2008).

The literature suggests that variations of both the AIDS (e.g., Kinnucan et al. 1997; Dameus et al 2002) and Rotterdam models (e.g., Cox 1992) provide successful results depending on the specific application and dataset used. For example, Kinnucan et al. (1997) suggest estimates from the absolute price Rotterdam are more consistent with U.S. meat demand than are those estimated with the LA/AIDS. Dameus et al (2002) found similar results to Kinnucan et al. using a Cox test based on parametric bootstrap to test a first-difference version of the AIDS model against the Rotterdam model. The results from the Cox test in Dameus et al. (2002) indicated that the Rotterdam model is superior to a first-difference version of the AIDS model for U.S. meat demand. In contrast, using Canadian data on fats and oils, Cox (1992) found that the absolute price version of the Rotterdam model produced unsatisfactory and theoretical inconsistent results, such as positive own-price elasticities and low levels of statistical significance. Alston and Chalfant (1993) suggested that the demand model specification should not be randomly chosen *ex-ante*. Rather, the authors suggested that the model specification should instead be based on its appropriateness with the dataset being used.

Both the absolute price version of the Rotterdam and the LA/AIDS were initially used to estimate the demand for foods in Canada and the U.S. However, the LA/AIDS model was finally selected based on its better fit with the dataset being used[15]. In addition, the LA/AIDS was selected due to its extensive history and use in food demand analysis, ability to incorporate demand shifters, ease of estimation in linear form, ability to aggregate over consumers, and the ability to incorporate the theoretical restrictions of demand theory.

4.2.2 The Linear Approximate Almost Ideal Demand System

This section discusses the derivation of the linear approximate almost ideal demand system (LA/AIDS). The almost ideal demand system was developed by Deaton and Muellbauer (1980), and is derived from the cost function for the price independent, generalized logarithmic (PIGLOG) class of preferences. Under the theorems of Meullbauer (1975, 1976), these preferences allow for aggregation over consumers. Following Deaton and Muellbauer (1980), the derivation of the AIDS originates with the cost function for the PIGLOG class of preferences defined by:

$$(1) \qquad \log c(u,p) = (1-u)\log\{a(p)\} + ulog\{b(p)\}$$

Where $c(u,p)$ denotes the cost function, u represents utility that lies between 0 (subsistence) and 1 (bliss), p represents a vector of prices, and *a(p)* and *b(p)* are functions of prices that represent the costs of subsistence and bliss. Deaton and Muellbauer selected

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[15] Initially, an absolute price version of the Rotterdam model was specified. However, the results showed low levels of statistical significance and estimates inconsistent with consumer demand theory such as positive own-price elasticities. The demand systems were also estimated using a first difference LA/AIDS and a quadratic AIDS with similar outcomes. The LA/AIDS model was finally selected as the best fit for this dataset. Interestingly, further research revealed that Cox (1992), Chang and Kinnucan (1991) and Goddard and Amuah (1989) also experienced similar inconsistencies with various AIDS (Chang and Kinnucan 1991; Goddard and Amuah 1989) and Rotterdam specifications (Cox 1992) when using aggregate Canadian data on fats and oils obtained from Statistics Canada.

the function for *log a(p)* based on acquiring a locally flexible functional form of the cost function, which required *log a(p)* have enough parameters, while the choice of functional form for *log b(p)* was based on the Engel curves developed by Working (1943) and Leser (1963, 1976) (Chalfant 1987). The functions of log a(p) and log b(p) are as follows (Deaton and Muelbauer 1980; Chalfant 1987):

(2) $$\log a(p) = a_0 + \sum_i a_i \ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij}^* \ln p_i \ln p_j$$

(3) $$\log b(p) = \log a(p) + \beta_0 \prod_k p_k^{\beta_k}$$

Substituting (2) and (3) into (1), the AIDS cost function is written as

(4) $$\log c(u,p) = a_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij}^* \ln p_i \ln p_j + u\beta_0 \prod_k p_k^{\beta_k}$$

By Shepherd's lemma, the derivatives of the cost function (4) with respect to prices result in expressions for quantities demanded (expressed as budget shares) as a function of prices and utility (Deaton and Muelbauer 1980). Since utility is not observed, the demand functions can be obtained by setting total expenditure, *X*, equal to cost, *c(u, p)*, based on a utility maximizing consumer, and inverting the equality to get indirect utility as a function of *p* and *X*. The results are the AIDS demand functions expressed in budget share form:

(5) $$w_i = \alpha_i + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln \left\{\frac{X}{P}\right\}$$

Where w_i denotes the consumer's budget share for good i, and a_i, γ_{ij} and β_i are parameters to be estimated. *P* represents a price index defined as:

(6) $$\ln P = \alpha_0 + \sum_j \alpha_j \ln p_j + \frac{1}{2}\sum_j \sum_i \gamma_{ij} \ln p_i \ln p_j$$

To obtain the linear approximate version of the AIDS (LA/AIDS), Stone's price index (P*) is used instead of P. It is defined as (Green and Alston 1990):

(7) $$\ln P^* = \sum_j w_j \ln P_j$$

The LA/AIDS can be written as follows:

(8) $w_{it} = \alpha_{it} + \sum_{it} \gamma_{ijt} \ln p_{jt} + \beta_{it} \ln \left\{\frac{X}{P^*}\right\}$, where $i = 1, \dots, N$ and $t = 1, \dots, T$

Based on the literature, it is assumed that health claims available on labels and in advertising influence consumer's tastes and preferences for foods resulting in a shift in demand. As a result, a dummy variable identifying the year of approval of the claim is added to the model as a demand shifter to identify whether there was a negative or positive impact on demand after the policy change[16]. In addition, a time trend is included to capture overall changes in consumer tastes and preferences over time. Following Cranfield (2012), a translating procedure is used that augments the intercept to incorporate the time trend and health claim dummy variables as follows (ignoring time subscripts):

(9) $\alpha_i = \alpha_{i0} + \alpha_i time + \alpha_{iHC} HC$

Where $time$ represents the time trend and HC represents a dummy variable reflecting the year in which health claims are approved. The health claim dummy variables take the value of zero for the years prior to the approval of the health claims and one thereafter. Last, α_{i0}, α_i, and α_{iHC} are parameters to be estimated. The new model can be written as follows:

(10) $w_i = (\alpha_{i0} + \alpha_i time + \alpha_{iHC} HC) + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln \left\{\frac{X}{P^*}\right\}$

The theoretical restrictions of homogeneity, symmetry and adding-up are imposed in the model as follow so that $\sum w_i \equiv 1$ holds. The restrictions are defined as follows:

(11) Homogeneity: $\sum_i \beta_i = \sum_i \gamma_{ij} = 0$

[16] The effects of the policy change were also considered to affect only the slope (through an interaction term between the policy dummy and price variables) or simultaneously impact the slope and cause a shift in demand. However, the use of only a dummy variable to indicate the change in policy was selected as the best fit with the dataset.

(12) Symmetry: $\gamma_{ij} = \gamma_{ji}$

(13) Adding-up: $\sum_i \alpha_i = 1$

Where homogeneity implies proportional increases in prices and total expenditure leaves demand unchanged. Symmetry is a cross-equation restriction that implies the matrix of substitution terms (cross-price derivatives) is symmetric. Lastly, the adding-up condition implies that the sum of the expenditures on each good is equal to the total expenditure for all goods or, in the case of share equations, the sum of all the budget shares is equal to one. These restrictions are important to maintain consumer demand theory of constrained utility maximization.

4.2.3 Elasticities

Since the LA/AIDS is a function of money income, calculated price elasticities are uncompensated (Marshallian) demand elasticities[17]. Elasticities describe the percentage change in budget shares for a 1% increase in prices or expenditures. The following formulas

[17] Many variations for calculating elasticities have been used in the literature. The most commonly reported elasticities are uncompensated elasticities. Only uncompensated (Marshallian) price elasticities are reported here and were calculated following Deaton and Muellbauer (1980), Green and Alston (1990), and Chalfant (1987). Compensated price elasticities were also calculated based on the formula provided by Pomboza and Mbaga (2007). However, when using the sample means to estimate compensated price elasticities for the Canadian dataset, the compensated own-price elasticity for salad oils in the fats and oils system and for beef in the meats system became positive. In contrast, when using the same formulas on the U.S. dataset for meats, there were no issues with compensated (and uncompensated) elasticities. The inconsistent results in the Canadian demand for fats could be due to Canada's supply management system in the dairy industry, which impacts dairy prices in Canada (CDIC 2017). Cox (1992), Goddard and Amuah (1989) and Chang and Kinnucan (1991) reported similar issues with positive own-price elasticities when using aggregated data on fats and oils obtained from Statistics Canada. As a result of the inconsistencies, only uncompensated elasticities are discussed as it appears that there could be some underlying issues with the Canadian dataset that need further investigation in future studies.

are used to calculate the price and expenditure elasticities at the sample means (Deaton and Muellbauer 1980; Chalfant 1987):

(14) Own-price elasticities: $\varepsilon_{ii} = -\delta_{ij} + \left(\frac{\hat{\gamma}_{ij}}{\bar{w}_i}\right) - \hat{\beta}_i$

(15) Cross-price elasticities: $\varepsilon_{ij} = -\delta_{ij} + \left(\frac{\hat{\gamma}_{ij}}{\bar{w}_i}\right) - \hat{\beta}_i \left(\frac{\bar{w}_j}{\bar{w}_i}\right)$

(16) Expenditure elasticities: $\eta_i = 1 + \frac{\hat{\beta}_i}{\bar{w}_i}$

Where δ_{ij} is the Kronecker delta and $\delta_{ij} = 1$ when $i = j$ and $\delta_{ij} = 0$ when $i \neq j$ and $\overline{w_i}$ represents the sample average of the budget share for good *i* and $\overline{w_j}$ represents the sample average of the budget share for good *j*.

To find the variances of the price elasticities, the variance operator is applied as follows:

(17) $Var(\varepsilon_{ij}) = \frac{1}{\bar{w}_i^2} Var(\hat{\gamma}_{ij}) + \frac{\bar{w}_j^2}{\bar{w}_i^2} Var(\hat{\beta}_i) - 2(\frac{\bar{w}_j}{\bar{w}_i^2}) Cov(\hat{\gamma}_{ij}, \hat{\beta}_i)$

(18) $Var(\eta_i) = \frac{1}{\bar{w}_i^2} Var(\hat{\beta}_i)$

4.2.4 Demand System Specifications

Two Canadian health claims and one U.S. health claim are analyzed for their impacts on the relevant food systems. The Canadian claims are with respect to 1) "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" and 2) "Fruits, Vegetables and Cancer (2000)". The U.S. claim is with respect to "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)". These claims are chosen for analysis based on their relevance to the top chronic illnesses (heart disease and cancer) in Canada and the U.S., the availability of sufficient data to analyze the impacts of the claims, and the similarity of the health claims regarding dietary fats and CHD in both Canada and the U.S. allow for comparisons to be made across countries[18].

Based on their relevance to the health claims that are analyzed in this thesis, the demand systems and commodities included in each system are as follows. In Canada, three demand systems are estimated. The first system is the demand for fats and oils over the period 1974 to 2016. The demand for fats and oils includes three share equations: 1) butter; 2) margarine; and 3) salad oils, and is specified as follows:

$$(19) \qquad w_i = (\alpha_{i0} + \alpha_i time + \alpha_{iHC} HC) + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln\left\{\frac{X}{P^*}\right\}$$

Where $i = 1,\ldots,3$ and represents the budget shares for butter, margarine and salad oils over the period 1974 to 2016. HC represents the health claim binary variable that takes the value of 0 before the approval of the health claim related to dietary fats and heart disease in 2000 and 1 thereafter. The remaining variables are as described in Section 4.2.2.

The applicable health claim to the Canadian fats and oils demand system was approved by Health Canada in 2000 and it is with regards to "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease". It is expected that this claim will negatively affect the budget share for butter as it contains higher levels of saturated and trans fats which are found to increase the risk for CHD[19] (American Heart Association 2017a). This claim is also expected to negatively affect margarine consumption. Prior to the approval of the dietary fats health claim (2000), many brands of margarine in Canada contained significant levels of trans fats (Ratnayake et al. 2007), In contrast, this claim is expected to have positive impacts on the consumption of salad oils. Salad oils contain

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[18] For more details on the health claims refer to Chapter 2.
[19] For more information on saturated fats and its sources see American Heart Association (2017) https://healthyforgood.heart.org/eat-smart/articles/saturated-fats

mono- and poly-unsaturated fats that are considered ‘heart healthy’, and public health authorities recommend most fat consumption come from mono- and poly-unsaturated fats (e.g., American Heart Association 2017a).

The second system in Canada is the demand for meats over the period 1979 to 2016. This system includes three share equations: 1) poultry; 2) pork; 3) beef, and is specified as follows:

$$(20) \qquad w_i = (\alpha_{i0} + \alpha_i time + \alpha_{iHC} HC) + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln \left\{\frac{X}{P^*}\right\}$$

Where $i = 1,\ldots,3$ and represents the budget shares for poultry, pork, and beef over the period 1979 to 2016. HC represents the health claim binary variable that takes the value of 0 before the approval of the health claim related to dietary fats and heart disease in 2000 and 1 thereafter. The remaining variables are as described in Section 4.2.2.

The relevant claim to the Canadian meat demand system was approved in 2000 and is with regards to “Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease”. It is expected that awareness of this claim will positively affect the budget share for poultry, which is lower in saturated fats, and negatively affect the budget shares for pork and beef, which are higher in saturated fats (American Heart Association 2017b). Previous research has indicated that there was significant consumer awareness about cholesterol information (non-advertising sources) during the 1990s that contributed to changes in consumption patterns of meats (see Section 3.2). It is expected that this public awareness will be a significant contributor to changing consumption patterns over time.

The third system in Canada is the demand for fruits and vegetables over the period 1985 to 2016. The demand for fruits and vegetables includes four share equations: 1) fresh fruits;

2) preserved fruits; 3) fresh vegetables; and 4) preserved vegetables[20], and is specified as follows:

$$(21) \qquad w_i = (\alpha_{i0} + \alpha_i time + \alpha_{iHC} HC) + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln \left\{\frac{X}{P^*}\right\}$$

Where i = 1,…,4 and represents the budget shares for fresh fruit, preserved fruit, fresh vegetables, and preserved vegetables over the period 1974 to 2016. HC represents the health claim binary variable that takes the value of 0 before the approval of the health claim related to dietary fats and heart disease in 2000 and 1 thereafter. The remaining variables are as described in Section 4.2.2.

The health claim relevant to this system was approved in 2000 and is with respect to "Fruits and Vegetables and Cancer". It is expected that the "Fruits and Vegetables and Cancer" claim will have positive impacts on the budget shares for all fruits and vegetables. However, there could be opposing effects on the preserved fruits and preserved vegetables categories. First, processing methods such as canning or cooking can have harmful effects on nutrients in fruits and vegetables (Rickman, Barrett and Bruhn 2007) and therefore consumers might turn to fresh products instead. In addition, health information relating to the negative health effects of excess sugars (Kimber 2016) and sodium (Farquhar et al. 2015) in processed foods could cause opposing negative impacts on preserved fruits and preserved vegetables compared to the positive impacts of the "fruits, vegetables, and cancer" claim.

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[20] Refer to Appendix 9 for a complete list of the fruits and vegetables included in the fresh fruits, preserved fruits, fresh vegetables, and preserved vegetables categories. The fruits and vegetables included in each category was based on available domestic disappearance data from Statistics Canada.

In that regard, the preserved fruits category includes more processed and sweetened fruit products, such as juices, canned fruits, and fruit fillings, which are not considered to be a good source of fruits and vegetables due to their higher sugar contents (Government of Canada 2013). Sugar consumption has been associated with several health issues including weight gain, insulin resistance, and CVD (Kimber 2016). As a result, it is expected that this might cause movement away from preserved fruits. The preserved vegetables category includes mostly frozen vegetables, but also some canned vegetables that can be considered part of a healthy diet if the sodium content is not too high (Government of Canada 2013). While sodium is essential to health, excess sodium can lead to high blood pressure, which is a risk factor for many illnesses (Farquhar et al. 2015). For these reasons, it is expected that the "Fruits and Vegetables and Cancer" claim should have positive impacts on all fruit and vegetable consumption. However, there could be opposing negative impacts from awareness of other types of health information on preserved fruits and vegetables consumption.

In the U.S., two demand systems are estimated based on available datasets, the relevance to the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" claim that was approved by the FDA in 1993, and to be consistent and comparable to the Canadian demand estimation. The first system is the demand for fats, which includes three share equations[21]: 1) butter; 2) margarine; and 3) lard, and is specified as follows:

(22) $$w_i = (\alpha_{i0} + \alpha_i time + \alpha_{iHC} HC) + \sum_i \gamma_{ij} \ln p_j + \beta_i \ln \left\{ \frac{X}{P^*} \right\}$$

[21] The demand for fats includes lard instead of salad oils, which is included in the Canadian demand analysis, due to limited availability of price data.

Where i = 1,…,3 and represents the budget shares for butter, margarine, and lard, over the period 1984 to 2010. HC represents the health claim binary variable that takes the value of 0 before the approval of the health claim related to dietary fats and heart disease in 1993 and 1 thereafter. The remaining variables are as described in Section 4.2.2. Butter and margarine products in the U.S. are assumed to be homogenous to those in Canada.

It is expected that the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" claim will negatively affect butter and lard demand due to their high saturated fat contents and positively affect margarine. At the time of approval of this claim, the significant adverse impacts of TFAs was not as well understood as SFAs. It is expected that when this claim was approved in the U.S. (1993), consumers might have viewed margarine as a better choice than other types of fat due to greater concerns and awareness about saturated fats.

The second U.S. system analyzed is the demand for meats, which includes three share equations: 1) poultry; 2) pork; 3) beef, and is specified as follows:

(23) $$w_i = (\alpha_{i0} + \alpha_i time + \alpha_{iHC} HC) + \sum \gamma_{ij} \ln p_j \, \beta_i \ln \left\{ \frac{X}{P^*} \right\}$$

Where i = 1,…,3 and represents the budget shares for poultry, pork, and beef over the period 1970 to 2016. The expectations for the impacts of the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" claim on this system are the same as in Canada. The budget share for poultry is expected to be positively impacted due to low levels of saturated fat while beef and pork share equations are expected to show negative effects due to higher levels of saturated fat content. Poultry, pork and beef products in the U.S. are assumed to be homogenous to those in Canada.

A summary of the demand systems that are estimated for each country, the commodities included in each system, the relevant health claim and its year of approval, and the expected impacts (+/-) of the related health claims on the budget shares for each commodity can be found in Table 1 below. It is assumed that butter, margarine, poultry, pork and beef are homogenous both within and across Canada and the U.S. Due to different regulations and farming practices, the quality and nutritional profiles of different agricultural commodities can vary across regions in Canada and the U.S. In the case of beef, Canada and the U.S. follow different grading systems, requirements, and standards that can affect the quality of the meat (Polkinghorne and Thompson 2010). Since health claims in Canada and the U.S. are broad in nature rather than related to specific products or brands, the homogenous products assumption is not expected to impact the outcome of health claims on demand.

Table 1. Summary of Demand Systems and Related Health Claims

Country	**Demand System**	**Commodities Included and Expected Impacts**	**Related Health Claims, Date of Approval and Descriptions**
Canada	Fats and Oils	Butter (-) Margarine (+) Salad oils (+)	"Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" • Saturated and trans fats are found to increase the risk for CHD • Butter contains high levels of saturated fats • Margarine and salad oils contain mono- and poly-unsaturated fats or 'heart healthy' fats – particularly salad oils
Canada	Meats	Poultry (+) Pork (-) Beef (-)	"Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" • Poultry contains lower levels of saturated fats

Country	Demand System	Commodities Included and Expected Impacts	Related Health Claims, Date of Approval and Descriptions
			• Pork and beef contain higher levels of saturated fats
Canada	Fruits and vegetables	Fresh fruit (+) Preserved fruit (+/-) Fresh vegetables (+) Preserved vegetables (+/-)	"Fruits, Vegetables and Cancer (2000)" • Phytonutrients found in fruits and vegetables might reduce risk of some types of cancers • Fruit and vegetable consumption is expected to increase in response to this information • Opposing health information about sugar and sodium in preserved fruits and vegetables might cause a shift towards fresh fruits and vegetables
U.S.	Fats and Oils	Butter (-) Margarine (+) Lard (-)	"Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (1993)" • Saturated and trans fats are found to increase the risk for CHD • Butter and lard contain high levels of saturated fats • Margarine contains mono- and poly-unsaturated fats
U.S.	Meats	Poultry (+) Pork (-) Beef (-)	"Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" • Poultry contains lower levels of saturated fats • Pork and beef contain higher levels of saturated fats

Source: Author

4.2.5 Estimation Methods

Zellner's (1962) seemingly unrelated regressions (SUR) approach is used to estimate five separate demand systems. This econometric approach is chosen because the demand equations are assumed to be connected through correlations across the error terms. In other words, the separate demand equations are not independent of each other so estimating all of them as a system rather than separately improves statistical inferences about the estimated parameters of the models. The following assumptions are made with regards to the SUR model:

(24) $E\left(u_{ih}' u_{ig}\right) \neq 0$ when $h \neq g$

(25) $E(u_{it} | \, x_i) = 0$, where $x_i = (x_{i1}, \ldots, x_{it})$

Where (22) assumes that the errors across equations are correlated and (23) assumes strict exogeneity of the explanatory variables (i.e., the error term is uncorrelated to the explanatory variables in all periods).

The theoretical conditions of homogeneity, symmetry and adding-up are imposed in the models. Due to the nature of the adding-up condition, one share equation is dropped in each demand system during estimation to avoid singularity of the variance-covariance matrix (Adhikari et al. 2006). The adding-up, homogeneity and symmetry conditions are then used to recover the parameters of the omitted equation (Dedah, Kiethly, and Kazmierczak 2011). To ease estimation of the parameters of the omitted equation, recover the standard errors, and check whether the constraints hold, the systems are re-estimated by including the omitted share equation from the first regressions and dropping a different share equation. Iterative SUR is used so that the parameter estimates converge to the maximum likelihood results and the parameters of the omitted equation can be recovered (Salman et al. 2010).

A typical assumption in applied demand analysis is that of weak separability (Eaves and Unnevehr 1988; Taljaard, Alemu and Van Schalkwyk 2004; Goddard and Amuah 1989; Deaton and Meulbauer 1999). Weak separability places assumptions on the structure of consumer preferences allowing for the demand for commodities to be separated into subgroups (Edgerton 1997). In this regard, consumers are assumed to follow a two-stage budgeting process. In the first stage, consumers allocate portions of their total income across broad categories of goods. In the second stage, consumers divide their group budgets amongst the individual commodities in the group.

4.2.6 Canadian Data

Per capita annual domestic disappearance data was used as a proxy for per capita consumption, which is common in the literature when analyzing demand at the aggregate level (e.g., Tonsor, Mintert and Schroeder 2010; Adhikari et al. 2006; Piggott and Marsh 2004; Adhikari et al. 2007). Domestic disappearance is a measure of the total food available for human consumption at the retail level (Statistics Canada 2016). Statistics Canada (2016) calculates domestic disappearance as the total supply of foods (which equals the sum of the beginning stocks plus production plus imports) less the flows out (exports, manufacturing and waste) and ending stocks. Per capita domestic disappearance is calculated by dividing the annual domestic disappearance by the population.

For the fats and oils demand system, per capita domestic disappearance quantities for butter, margarine and salad oils are obtained from Statistics Canada (2017a) *CANSIM table 002-0011 – Food Available in Canada* for the years 1974 to 2016. As for the meats demand system, per capita quantities of poultry, pork and beef are obtained from Statistics Canada (2017b) *CANSIM table 002-0011 – Food Available in Canada* for the years 1979 to 2016. The per capita quantity of poultry is calculated as the sum of chicken, stewing hen, and turkey on an eviscerated weight basis. The per capita quantity of beef is calculated as the sum of beef and veal on a retail weight basis. The per capita quantity of pork is obtained on a retail weight basis.

For the fruits and vegetables demand system, per capita quantities of fresh fruits, preserved fruits, fresh vegetables, and preserved vegetables are obtained from Statistics Canada (2017c) *CANSIM table 002-0011 – Food Available in Canada* for the years 1985 to 2016. Per capita quantity of fresh fruits is calculated as the sum of all fresh fruits. The per capita quantity of preserved fruits is the sum of all fruit juices, canned fruits and frozen fruits. The per capita quantity of fresh vegetables is the sum of all fresh vegetables. The per capita quantity of preserved vegetables is the sum of all frozen and canned vegetables. Only those fruits and vegetables that had data available for the relevant time period (1985 to 2016) were included in each category. For more detailed information on the fruits and vegetables included in each category see Appendix 9.

Following Brester and Schroeder (1995), the consumer price index (CPI) by food group was used as a proxy for prices[22]. Statistics Canada calculates the consumer price index for various food groups using a weighted arithmetic average and then indexes prices to a base year, which is currently 2002. Price data for the fats and oils demand system is obtained from Statistics Canada (2017d) *CANSIM table 326-0020 – Consumer Price Index*. This table provides CPI data for butter, margarine, and 'other oils', which is used to proxy for the price of salad oils[23]. For the meats demand system, the price data is obtained from

[22] Average retail prices were used initially. However, the earliest available average retail price data was from 1995 and this did not provide enough observations to estimate the models.

[23] Based on the domestic disappearance data in CANSIM table 002-0011, most 'other oils' in Canada are salad oils (i.e., vegetable oils). As a result, 'other oils' is used as a proxy for the price of salad oils since there is no category for salad oils under the CPI.

Statistics Canada (2017e) *CANSIM table 326-0020 – Consumer Price Index*. This table provides CPI data for 'fresh or frozen poultry', 'fresh or frozen beef', and 'fresh or frozen pork', which are used as a proxy for poultry, beef and pork prices. Last, the price data for the fruits and vegetables demand system is obtained from Statistics Canada (2017f) *CANSIM table 326-0020 – Consumer Price Index*. This table provides CPI data for 'fresh fruit', 'preserved fruit and fruit preparations' (proxy for preserved fruit price), 'fresh vegetables', and 'preserved vegetables and vegetable preparations' (proxy for preserved fruit price).

4.2.7 U.S. Data

Per capita annual domestic disappearance data on a retail weight basis was used to proxy for annual per capita consumption of fats and meats in the United States. Domestic disappearance data for fats was obtained from Economic Research Services (ERS), U.S. Department of Agriculture's Oil Crops Yearbooks for the years 1974 to 2016. In particular, quantity data for margarine was obtained from ERS (2017b) *Table 40 - Margarine (actual weight): Supply and disappearance, U.S., 1980-2010.* Quantity data for lard was obtained ERS (2017c) *Table 42--Lard: Supply, disappearance, and price, U.S., 1980-2016*. Quantity data for butter was obtained from ERS (2017d) *Table 43--Butter (actual weight): Supply, disappearance, and price, U.S., 1980-2016*.

Per capita domestic disappearance data for poultry, pork, and beef in the meat demand system was obtained from the ERS (2017a) *Food Availability (Per Capita) Data System* for the years 1970 to 2016. The per capita quantity of poultry is calculated as the sum of chicken, broilers, and turkey on an eviscerated weight basis. The per capita quantity of beef is calculated as the sum of beef and veal on a retail weight basis. The per capita quantity of pork is obtained on a retail weight basis.

There were no U.S. CPI datasets available for fats that were comparable to those used in the Canadian demand estimation. Based on the best available dataset, average retail prices are of margarine, lard, and fat in the U.S from 1970 to 2016 are used for analysis. The average retail price of margarine was obtained from BLS (2017a), series ID *APU000716114.* The price of margarine was missing for the years 1997 to 1999. Since observations already were limited and the price didn't vary much over those years, the price of 1996 was used for 1997 and the price of 2000 for 1999. For 1998, the average price of 1996 and 2000 was used. Average retail price of lard was obtained from ERS (2017c) *Table 42--Lard: Supply, disappearance, and price, U.S., 1980-2016*. Average retail price data for butter was obtained from ERS (2017d) *Table 43--Butter (actual weight): Supply, disappearance, and price, U.S., 1980-2016*.

As for prices in the meat demand system, to make the datasets comparable and consistent to those used in Canada, the U.S. consumer price indices for poultry, pork and beef are used to proxy for prices from 1970 to 2016. The CPI for poultry is obtained from BLS (2017b) series ID *CUUR0000SEFF*, the CPI for pork is obtained from BLS (2017c) series ID *CUUR0000SEFD*, and, last, the CPI for beef is obtained from BLS (2017d) series ID *CUUR0000SEFC*. A summary of the descriptions and sources for all data used in this thesis is provided in Appendix 8.

4.3 Population Health Status: A Health Production Function

When evaluating the factors that affect health at the aggregate level, population health is frequently modeled as a health production function (e.g., Or 2001; Thornton 2002; Shaw, Horrace and Vogel 2005; Joumard et al. 2008). In this regard, health is 'produced' by several socio-economic, environmental and lifestyle factors that are considered 'inputs' in the production of health (Or 2001; Auster, Leveson, and Sarachek 1969). While it is challenging to capture all the aspects that contribute to the quality, length of life and overall well-being in one variable (Or 2001; Romley and Sood 2013), both measures of life expectancy and mortality have been considered the most appropriate representations for population health status (Joumard et al. 2008) and are consistently used as a proxy for health status in the literature (e.g., Filmer and Pritchett 1999; Shaw, Horrace and Vogel 2005; Fayissa and Gutema 2005; Anand and Barnighausen 2004; Or 2001). Life expectancy and mortality rates are the most common proxies because data on life expectancy and mortality are typically comparable across countries (Or 2001) and are widely available over extended periods of time (Joumard et al. 2008)[24].

To evaluate the impacts of health claims and changes over time in the health status of North Americans, a logarithmic health production function with country fixed-effects for Canada and the U.S. is estimated for the years 1990 to 2011. The same Canadian health claims regarding 'Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)' and 'Fruits and Vegetables and Cancer (2000)' evaluated in the demand analysis are examined for their impacts on population health status. Due to limited data availability, only the impacts of the Canadian health claims could be evaluated. In addition, data limitations required data for Canada and the U.S. to be pooled and estimated as a single regression for 'North America'. However, country fixed effects are used to account for unobserved differences across countries that might affect health status in each country (Joumard et al. 2008). In this case, a binary variable that takes the value zero when the country is the U.S. and one when the country is Canada is used to capture the country fixed effects. A log-linear functional form is used to capture the non-linear relationship

[24] The choice of mortality or longevity as a dependent variable does not appear to be that critical to the results (e.g., Joumard et al. 2008).

between the ‘inputs’ (i.e., the independent variables) and health status (Filmer and Pritchett 1999).

Consistent with previous literature, female and male life expectancies at age 65 are used to capture the health status (e.g., Joumard et al. 2008; Miller and Frech 2000; Shaw, Horrace, and Vogel 2005) of North Americans. The use of life expectancy at age 65 as a proxy for health is beneficial because it provides information about the health of older populations that other measures, for example, infant or maternal mortality rates, do not provide (Joumard et al. 2008). Further, in comparison to life expectancy at birth, there are greater variations in life expectancy at age 65 (Joumard et al. 2008).

As for the independent variables, socioeconomic (income, education, and healthcare resources), lifestyle (diet, alcohol consumption, and tobacco consumption), and environmental (pollution) factors are included as inputs in the production of health in North America. Income can benefit health outcomes by improving access to necessities such as food, shelter, and hygiene (Filmer and Pritchett 1999). Education is viewed as supporting better decision making abilities and facilitating preventative care behaviours leading to improved health (Wolfe and Berhman 1984; Brunello et al. 2016). Last, the provision of healthcare resources means greater access to direct medical attention that can improve and mitigate health issues (Or 2001; Filmer and Pritchett 1999; Thornton 2002).

In addition to socioeconomic factors, lifestyle is an important factor for population health status and is typically captured by diet, alcohol, and tobacco consumption (e.g., Joumard et al. 2008; Shaw, Horrace and Vogel 2005; Or 2001). Diet is a significant contributor to current and future health outcomes and is considered one of the major worldwide risks to health (WHO 2015). Poor diets can lead to weight gain, high cholesterol and several other risk factors for the development of chronic diseases later in life, such as

CVD, obesity, diabetes and some forms of cancer (WHO 2003). Fruit, vegetable, fat, and sugar consumption or caloric intakes have been used as a proxies diet (e.g., Shaw, Horrace and Vogel 2005; Joumard et al. 2008; Fayissa and Gutema 2005; Thornton 2002). As for tobacco consumption, research has shown that smoking greatly increases the risk for heart disease, stroke and lung cancer (CDC 2017b). In the United States, tobacco consumption is estimated to be the cause of approximately one in five deaths (CDC 2017b). Similarly, the detrimental effects of unhealthy levels of alcohol consumption can have serious consequences on health (WHO 2014). Alcohol consumption is reported to be a contributing factor in more than 200 different illnesses (WHO 2014).

Four different models are estimated. Model 1 and Model 2 use male life expectancy at age 65 as the dependent variable. Model 3 and Model 4 use female life expectancy at age 65 as the dependent variable. Model 1 and Model 3 examine changes in female and male life expectancy at age 65 over time. Model 2 and Model 4 build upon the demand analysis in the previous section and evaluate the impacts of the approval Canada's health claims regarding 'Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)' and 'Fruits and Vegetables and Cancer (2000)' on male and female health status, respectively. Due to limited data availability prior to 1990, the impacts of the U.S. health claims approved in 1993 could not be evaluated.

The four models are specified as follows:

(26) **Model 1:** $\ln(LE65_{Male}) = \ln(SMOKE) + \ln(DRINK) + \ln(FV) + \ln(FAT) + \ln(DOCTOR) + \ln(GDP) + \ln(POL) + CANADA + TIME + \varepsilon_1$

(27) **<u>Model 2:</u>** $\ln(LE65_{Male}) = \ln(SMOKE) + \ln(DRINK) + \ln(FV) + \ln(FAT) + \ln(DOCTOR) + \ln(GDP) + \ln(POL) + CANADA + TIME + \ln(\mathrm{FAT}) * \mathrm{HC2000} + \ln(\mathrm{FV}) * \mathrm{HC2000} + \varepsilon_2$

(28) **<u>Model 3:</u>** $\ln\left(LE65_{female}\right) = \ln(SMOKE) + \ln(DRINK) + \ln(FV) + \ln(FAT) + \ln(DOCTOR) + \mathrm{EDUC} + \ln(POL) + CANADA + TIME + \varepsilon_2$

(29) **<u>Model 4:</u>** $\ln\left(LE65_{female}\right) = \ln(SMOKE) + \ln(DRINK) + \ln(FV) + \ln(FAT) + \ln(DOCTOR) + \mathrm{EDUC} + \ln(POL) + CANADA + TIME + \ln(\mathrm{FAT}) * \mathrm{HC2000} + \ln(\mathrm{FV}) * \mathrm{HC2000} + \varepsilon_4$

where $LE65_{MALE}$ is male life expectancy at age 65; $LE65_{FEMALE}$ is female life expectancy at age 65; SMOKE is annual tobacco consumption per capita; DRINK is annual liters of alcohol consumed per capita; FAT is annual fat consumed per capita; FV is annual fruits and vegetables consumption per capita; DOCTOR is number of doctors per 1000 people; GDP is annual real GDP per capita; POL is annual per capita emissions of nitrous oxide (NO_x); CANADA is a binary variable that takes the value of 1 when the country is Canada and 0 when the country is the U.S.

Last, HC2000 is a binary variable to indicate the year (2000) the two Canadian health claims analyzed in the demand section were approved. It takes the value of zero prior to 2000 and one thereafter. Since the two health claims being analyzed relate to the consumption of dietary fats (Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease) and the consumption of fruits and vegetables (Fruits and Vegetables and Cancer), the health claim binary variable has been included as affecting the slope[25] of the health production function through changes in fat consumption and fruit and vegetable consumption. To capture these impacts, the following interaction terms are included in equation (27) and (28): $\ln(\mathrm{FAT}) * \mathrm{HC2000}$ and $\ln(\mathrm{FV}) * \mathrm{HC2000}$. All variables are specified in natural logarithm expect CANADA and EDUC. A summary of these variables and their descriptions is provided in Appendix 10.

Similar to previous literature (e.g., Or 2001; Fayissa and Gutema 2005; Cremieux, Oullette and Pilon 1999; Joumard et al. 2008), the population health models are estimated using iterative feasible generalized least squares (FGLS) with heteroskedasticity corrected standard errors. FGLS is a method for estimating unbiased parameters of linear models when heteroskedasticity of unknown form is present in panel data (Wooldridge 2010). Heteroskedasticity occurs when the variance of the errors is not constant across observations. FGLS is used to estimate the unknown structure of the variance-covariance matrix from the OLS regression. Iterative FGLS is used to make the estimates converge to the maximum likelihood estimation.

4.3.1 Data

The data used in the analysis of population health status is North America is obtained from the OECD (2017) Health Statistics 2016 database. All variables are measured on an annual basis. Life expectancy variables are measured in years. Tobacco consumption (SMOKE) is measured in kilograms of tobacco consumed per capita, age 15 years or older. Tobacco consumption was converted from grams to kilograms by dividing by 1000. Alcohol consumption (DRINK) is measured as liters of alcohol consumed per capita, age

[25] The models were also estimated with health claims affecting only the intercept term and the intercept and slope terms. However, the models did not produce meaningful results. The models with health claims affecting the slopes were selected as they provided the most meaningful and statistically significant results.

15 years and older. Fat consumption (FAT) is measured as grams of fat consumed per capita. Fat consumption was converted from daily grams consumed to annual kilograms consumed by multiplying by 365 and dividing by 1000.Fruit and vegetable consumption is measured as kilograms of fruits and vegetables consumed per capita. Fruit and vegetable consumption is the sum of annual kilograms of fruit per capita and annual kilograms of vegetables per capita. GDP is measured in U.S. dollars per capita, constant prices, constant exchange rates, OECD base year (2010). Education (EDUC) is measured as the percentage of the population age 25 to 64 with at least upper secondary education. Healthcare resources (DOC) are measured by professionally active physicians per 1000 population.

4.4 Summary

This section presented two models that could be used to, first, analyze the impacts of health claim policy on the demand for functional foods and, second, analyze the impacts on population health. The first model is a linear approximate almost ideal demand system (LA/AIDS) that will be used for evaluating the impacts of two Canadian health claims and one comparable U.S. health claim on food demand in each country. The first Canadian health claim, "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)", is analyzed for its impacts on the demand for fats and oils and the demand for meats in Canada. The second Canadian health claim, "Fruits, Vegetables and Cancer (2000)", is evaluated for its impacts on the demand for fruits and vegetables in Canada. In the U.S., the approval of a comparable health claim regarding "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" is analyzed for its impacts on the demand for fats and the demand for meats in the U.S.

The second model is a logarithmic health production function that is used to evaluate changes in the health status of North Americans (Canada and the U.S.) over time and as a result of changes in consumption patterns facilitated by health claim policy. Life expectancy is used as a proxy for health status and a binary variable is used to capture changes in health claim policy. Based on data availability, only the approval of the two Canadian health claims are evaluated for their impacts on health.

CHAPTER 5

5. Empirical Results

This chapter presents the empirical results for the impacts of health claim regulations on the demand for functional foods and population health status in North America. The first part of this chapter presents the econometric results from the estimated demand systems for 1) fats and oils, 2) meats, and 3) fruits and vegetables in Canada and 1) fats and oils and 2) meats in the U.S. As discussed in Chapter 4, the two Canadian health claims that are evaluated for their impacts on the Canadian demand systems and the year they were approved are 1) "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" and 2) "Fruits, Vegetables and Cancer (2000)". The U.S. health claim that is evaluated for its impacts on U.S. food demand and its year of approval is "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (1993)".

The linear approximate almost ideal demand system (LA/AIDS) is used as the functional form for all the estimated demand systems. Zellner's iterative seemingly unrelated regressions (ITSUR) is used to estimate the demand for the goods in each system and the theoretical conditions of homogeneity, symmetry and adding-up are imposed in the models. The assumption that groups of goods are weakly separable allows for the estimation of separate demand systems in Canada and the U.S. (see Chapter 4 for more information on estimation methods).

The discussion of the empirical results for the demand analysis portion of this chapter are organized as follows. First, the results from the Breusch-Pagan test of independence are discussed. Next, the parameter estimates for the price, expenditure, health claim, and time variables are interpreted and reviewed for their statistical significance in the Canadian demand systems followed by the U.S. demand systems. The parameter estimates for the price and expenditure variables are discussed only regarding their statistical significance since they provide limited meaning. Instead, the price and expenditure elasticity estimates are included in the discussion of the empirical results for the Canadian and U.S. demand analysis.

The second part of this chapter presents the econometric results from the estimated health production function for Canada and the U.S. The health production function assesses the impacts of health claim regulations on population health status and changes in health over time in North America. As discussed in Chapter 4, population health status is captured by male life expectancy at age 65 and female life expectancy at age 65. The model also includes income, education, healthcare resources, diet, tobacco consumption, alcohol consumption, and pollution as determinants of health. The discussion of the empirical results for the population health portion of this chapter are organized as follows. First, the results and impacts of health claim regulations on male life expectancy at age 65 and changes in male health status over time are reviewed. Second, the results and impacts of health claim regulations on female life expectancy at age 65 and changes in female health status over time are reviewed.

5.1 Breusch-Pagan Test of Indepedence

As discussed in Chapter 4, the SUR approach is used to estimate a series of separate equations as a system rather than individually due to the assumption that there is correlation among the random error terms that should be considered during estimation to improve statistical inference. The Breusch-Pagan (BP) test of independence is a test used to evaluate the appropriateness of SUR estimation by testing for correlation among the residuals in the share equations. If the null hypothesis that the correlation among the errors is zero is rejected, then SUR is an appropriate estimation method (Wooldridge 2010).

For the fruits and vegetables system, a chi-squared test statistic of 25.279 and p-value of 0.00 indicate that the null hypothesis that the correlation among the errors is zero can be rejected at the 1% significance level. Similarly, in the fats and oils system, a chi -squared test statistic of 29.045 and p-value of 0.00 indicates rejection of the null hypothesis at the 1% level, and for the Canadian meats system, a chi-squared test statistic of 8.712 and p-value of 0.0032 indicate rejection of the null at the 1% level. In the U.S. meat system, a chi-square test statistic of 8.543 and p-value of 0.0035 indicate rejection of the null hypothesis at the 1% level. Based on the results of the BP tests, all systems showed correlation among the error terms of each equation and are estimated using seemingly unrelated regressions.

5.2 The Demand for Fats and Oils in Canada

Growing awareness about the relationship between dietary fats and CHD since the 1980s (Wasink and Cheney 2005) coincided with significant changes in the annual per capita consumption[26] of butter, margarine, and salad oils in Canada. The annual per capita consumption of fats and oils in Canada from 1974 to 2016 is shown in Figure 2. The graph shows that there was a drastic increase in the annual per capita consumption of salad oils around 1992 until 2001 after which it began to level off. In comparison, the annual per capita consumption of butter and margarine in Canada appears to have declined gradually compared to salad oils. The increase in the per capita consumption of salad oils and decrease in the per capita consumption of margarine and butter make sense given the

[26] Per capita domestic disappearance data (also known as food available for human consumption) is used as a proxy for per capita consumption as discussed in Section 4.2.6.

changes in the understanding of the different roles of saturated, trans, monounsaturated, and polyunsaturated fats on health and cholesterol that occurred since the 1980s (see Section 2.4 for more information).

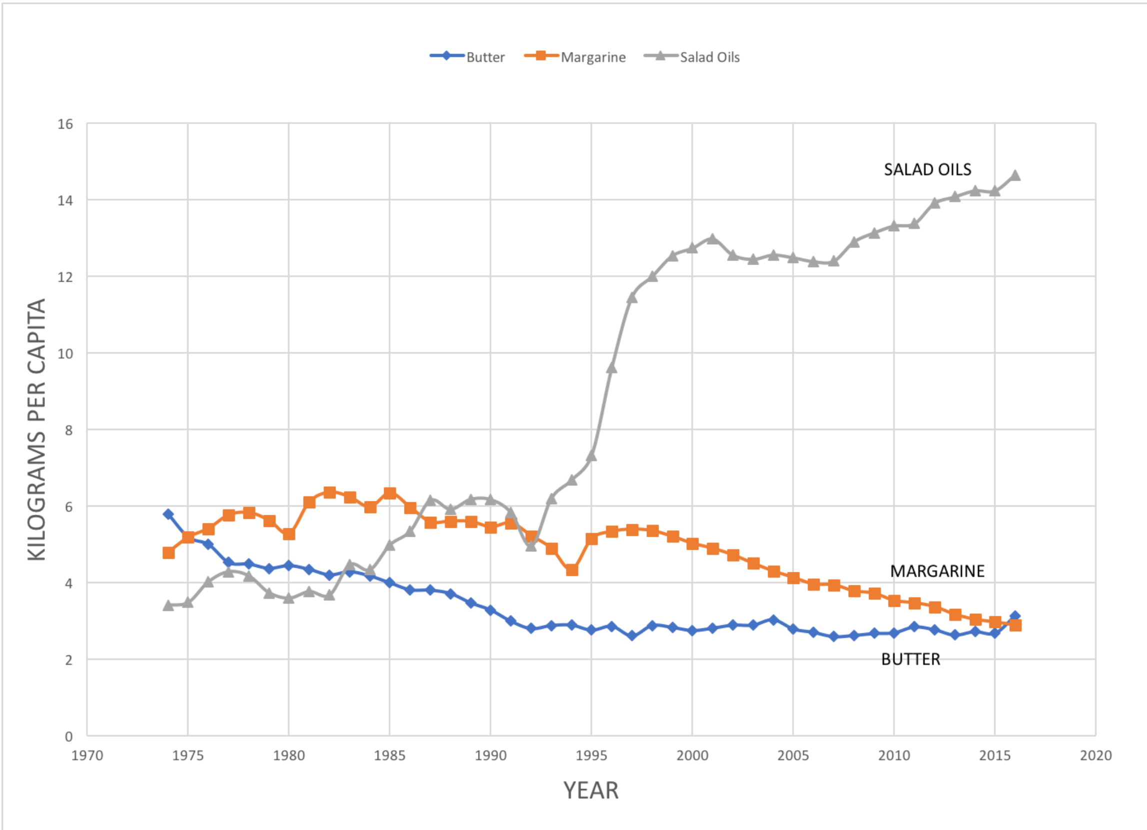

Figure 2. Consumption of Fat in Canada, 1974 to 2016

Source: Statistics Canada (2017a)

The coefficient estimates for the demand for fats and oils in Canada (1974 to 2016) are shown in Table 2. The coefficient estimates for the price and expenditure variables are discussed only for their statistical significance as they provide limited meaning. Instead, the price and expenditure elasticity estimates are presented and interpreted later. In that regard, fats and oils are divided into three categories: butter, margarine and salad oils. Overall, the share equation for butter has an R^2 of 0.888 indicating that this regression explains 88.8% of the variation in the budget share for butter. The coefficient estimates for the butter share equation show that butter's own-price is statistically significant at the 5% level while the price for margarine, the price of salad oils, and the expenditure variable are statistically significant at the 1% level. The time trend for the butter share equations is statistically significant at the 10% level and indicates that, on average, the budget share of butter declined by 0.25% per year over the period. The health claim variable did not show statistically significant impacts on the consumption of butter.

The share equation for margarine produced an R^2 of 0.958. In the margarine share equation, margarine's own-price is statistically significant at the 5% level, the prices of butter and salad oils are statistically significant at the 1% level, and the expenditure variable is statistically significant at the 10% level. The time trend is statistically significant at the 1% level and indicates that, on average, the budget share of margarine declined by 0.53% per year over the sample period. The health claim variable is statistically significant at the 1% level and indicates that, on average, the budget share for margarine was 8.3% lower than it was prior to the approval of the health claim regarding dietary fats and CHD in 2000.

As for salad oils, the share equation has an R^2 of 0.957. The expenditure variable and all price variables in the salad oil share equation are statistically significant at the 1% level. The time trend is also statistically significant at the 1% level and indicates that, on average, the budget share for salad oils increased by 0.77% per year over the sample period. indicating a positive trend in consumption of salad oils over the period. The health claim variable in the salad oil share equation is not statistically significant.

Table 2. Coefficient Estimates - Demand for Fats and Oils in Canada

Independent Variables	Share Equation		
	Butter	**Margarine**	**Salad Oils**
Butter Price	0.101**	0.113***	-0.214***
	(-0.044)	(-0.036)	(-0.067)
Margarine Price	0.113***	0.132**	-0.245***
	(-0.036)	(-0.064)	(-0.086)
Salad Oil Price	-0.214***	-0.245***	0.459***
	(-0.067)	(-0.086)	(-0.135)
Expenditure	-0.125***	-0.0558*	0.180***
	(-0.039)	(-0.033)	(-0.056)
HC2000	0.021	-0.0383***	0.018
	(-0.013)	(-0.011)	(-0.019)
Time	-0.0025*	-0.0053***	0.0077***
	(-0.001)	(-0.001)	(-0.002)
Constant	0.973***	0.768***	-0.741**
	(-0.200)	(-0.168)	(-0.290)
Observations	43	43	43
R-squared	0.888	0.958	0.957

Standard errors reported in parentheses
Significance at 1%***, 5%** , and 10%* level

Source: Author

The significant impacts of the health claim variable on margarine consumption is not surprising since margarine contained high levels of TFAs during the 1980s and 1990s (see Section 2.4 for more information). In addition, based on the prevalence of both heart disease and its risk factors (e.g., high blood pressure, high blood cholesterol, excess weight) among Canadians (see Section 2.1 for more information), it makes sense that consumers would be responsive to health advice related to CHD. As for butter and salad oils, the large volume of published research and media attention (non-advertising sources) regarding the role of saturated fats on health that occurred during the 1990s likely motivated consumers to begin altering their diet prior to the approval of the Canadian health claim in 2000. The significance of the time trends in the butter, margarine, and salad oil share equations supports the idea that consumers have been adjusting their consumption patterns towards fats and oils that are lower in saturated and trans fats over the entire sample period based on awareness from non-advertising sources.

The price and expenditure elasticities for butter, margarine and salad oils are reported in Table 3. The own-price elasticity estimates for butter (-0.359), margarine (-0.505), and salad oils (-0.269) are negative and consistent with demand theory. For example, this means that, all else constant, a 1% increase in the price of butter is expected to decrease the budget share for butter by 0.359%. Similarly, all else equal, a 1% increase in the price of margarine is expected to decrease the budget share of margarine by 0.505% and a 1% increase in the price of salad oils is expected to decrease the budget share for salad oils by 0.269%. While margarine is the most sensitive to its own-price, all three types of fats and oils showed inelastic own-price sensitivity.

The cross-price elasticities reveal that butter and margarine are weak substitutes for each other with the price of margarine having only slightly larger impacts on the demand for butter (0.769) than vice versa (0.412). For example, a 1% increase in the price of margarine is expected to increase the demand for butter by 0.769%, *ceteris paribus*. Similarly, a 1% increase in the price of butter is expected to increase the demand for margarine by 0.412%, *ceteris parabus*. In contrast, salad oils and butter and salad oils and margarine are complements. The results show that the price of salad oils has slightly larger impacts on butter demand (-0.772) than margarine demand (-0.722). In addition, increases in the price of butter has weak negative impacts on the demand for salad oils (-0.495) as well as increases in the price of margarine on salad oil demand (-0.594).

Table 3. Elasticity Estimates - Fats and Oils in Canada

	Share Equation		
Independent Variables	**Butter**	**Margarine**	**Oils**
Butter Price	-0.359*	0.412***	-0.495***
	(0.244)	(0.123)	(0.130)
Margarine Price	0.769***	-0.505**	-0.594***
	(0.208)	(0.210)	(0.174)
Oils Price	-0.772**	-0.722**	-0.269
	(0.402)	(0.299)	(0.261)
Expenditure	0.361**	0.814***	1.357***
	(0.199)	(0.109)	(0.112)

Standard errors reported in parentheses
Significance at ***1%, **5%, and *10% level

Source: Author

These cross-price elasticities intuitively make sense based on the types of applications for the different fats and oils. First, butter and margarine have a similar consistency and might be more appropriate substitutes when used as a spread or in baking. In contrast, oil has a very different consistency and consumers might not be able to substitute oil for butter or margarine as a spread or in baking. Likewise, if oil is used in, for example, salad dressings, butter and margarine might not be viewed as an appropriate substitute. Therefore, the complementary nature between salad oils and butter and salad oils and margarine also intuitively makes sense.

In addition, the Canadian demand for fats might be affected by the supply management system that is implemented in the Canadian dairy sector. Supply management refers to a system where dairy farmers jointly negotiate domestic production quotas, prices, and import restrictions to regulate the supply of dairy products in Canada (CDIC 2017). Supply management is used to stabilize market conditions and provide income security for dairy farmers (DFC n.d.). However, supply management results in higher prices for consumers in Canada (Cartel and Merel 2016; Cardwell, Lawley, and Xiang 2015). Price and quantity restrictions that result in higher prices might result in the demand for butter being lower than what is socially optimal and impact how consumers decide to allocate their expenditures across all fats in the Canadian demand system. However, the supply management system implemented in Canada is not expected to affect the main results of this thesis or, in other words, how consumers choose to respond to health information provided in health claims.

The expenditure elasticities of 0.361 for butter, 0.814 for margarine, and 1.357 for salad oils indicates that all three products are normal goods. Further, salad oils have the strongest sensitivity to changes in income and butter have the weakest. For example, a 1% increase in income is expected to increase the budget share of salad oils by 1.357%, all else equal.

The own-price and expenditure elasticities also are not surprising as they are consistent with previous studies. The elasticity estimates for fats and oils are comparable to Chang and Kinnucan (1991) who also reported inelastic own-price estimates for butter (-0.74), margarine (-0.09) and salad oils (-0.29), that butter is a substitute for margarine (0.15), and that expenditure elasticities are greatest for salad oils (1.43) and weakest for butter (0.71) in Canada. Further, using Canadian data, Goddard and Amuah (1989) also found that butter (-0.72), margarine (-0.60), and oils (-0.14) have inelastic own-price sensitivity, that oils are least sensitive to own-price (-0.14), and that the price of oils had a complementary relationship with butter demand (-0.08). Goddard and Amuah (1989) suggest that consumers might allocate a somewhat fixed amount of their budget on food towards the purchase of fats and oils, therefore as the price of one increases, the total consumption of fats and oils must fall to preserve this level of spending, accounting for the complementary relationship between salad oils and butter and salad oils and margarine.

5.3 The Demand for Meats in Canada

The annual per capita consumption (domestic disappearance) of poultry, pork, and beef available in Canada has changed considerably since 1979. The annual per capita consumption of poultry, pork, and beef in Canada from 1979 to 2016 is shown in Figure 3. The graph reveals that pork and beef consumption in Canada has gradually trended downwards over the sample period while poultry consumption has had quite a steeper upward trend. These patterns make sense given the volume of information regarding saturated fats and CHD (see Section 2.4 for more information) and advice from health professionals to limit intakes of red meat such as beef and pork (e.g., American Heart Association 2017b).

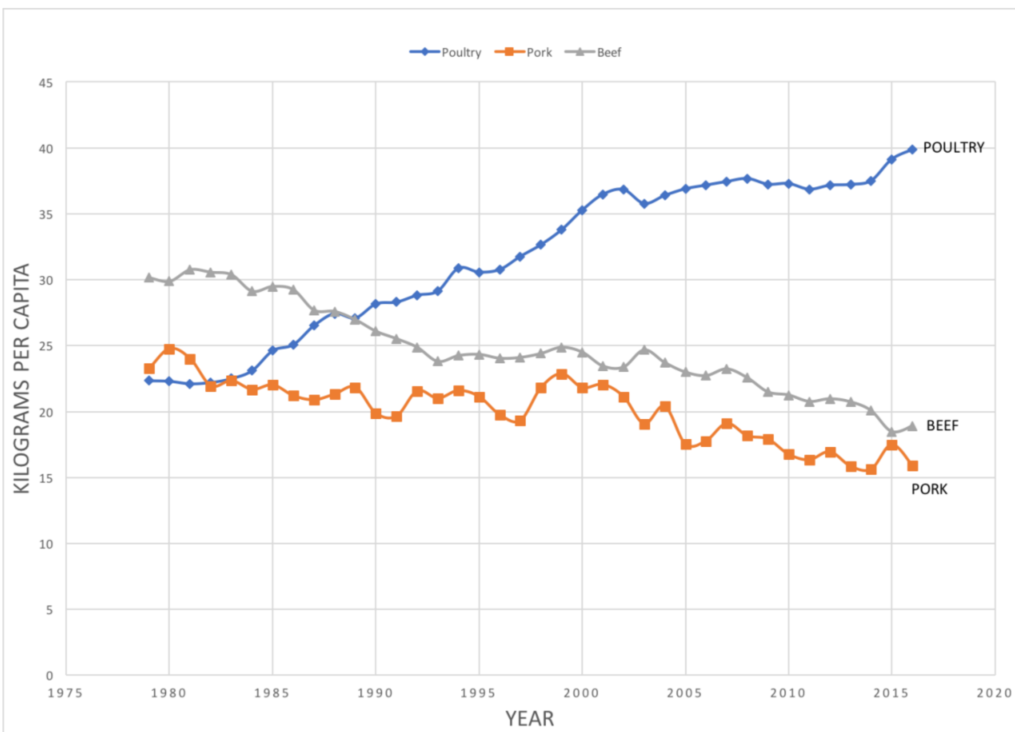

Figure 3. Consumption of Meat in Canada, 1979 to 2016

Source: Statistics Canada (2017b)

The coefficient estimates for the demand for meats in Canada from 1979 to 2016 are shown in Table 4 (for more information on the demand systems see Section 4.2.4). The share equation for poultry has an R^2 of 0.989. The results for the poultry share equation show that poultry's own-price, the price of pork, and the price of beef are statistically significant at the 1% level. The health claim variable did not show statistically significant impacts on the consumption of poultry. However, the time trend is significant at the 1% level and indicates that, on average, the budget share of poultry increased by 0.59% per year over the period.

Table 4. Coefficient Estimates - Demand for Meats in Canada

	Share Equation		
Independent Variables	**Poultry**	**Pork**	**Beef**
Poultry Price	0.231***	-0.0782***	-0.153***
	(-0.025)	(-0.021)	(-0.016)
Pork Price	-0.078***	0.148***	-0.0699***
	(-0.021)	(-0.024)	(-0.017)
Beef Price	-0.153***	-0.0699***	0.223***
	(-0.016)	(-0.017)	(-0.021)
Expenditures	0.0421	0.0831*	-0.125**
	(-0.043)	(-0.047)	(-0.052)
HC2000	0.00105	-0.0140**	0.0130*
	(-0.006)	(-0.007)	(-0.007)
Time	0.0059***	-0.0040***	-0.0019*
	(-0.001)	(-0.001)	(-0.001)
Constant	-0.0118	-0.263	1.274***
	(-0.3)	(-0.324)	(-0.357)
Observations	38	38	38
R-squared	0.989	0.963	0.943

Standard errors reported in parentheses
Significance at *** 1%, ** 5%, * 10% level

Source: Author

Overall, the share equation for pork has an R^2 of 0.963. The results show that pork's own-price, the price of poultry, and the price of beef are statistically significant at the 1% level, and the expenditure variable is significant at the 10% level. The health claim variable is statistically significant at the 5% level and indicates that the demand for pork was, on average, 1.40% lower after the approval of the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease" claim in 2000. In addition, the time trend for the pork share equation is statistically significant at the 1% level and indicates that the budget share for pork decreased by approximately 0.40% per year over the sample period.

Overall, the share equation for beef has an R^2 of 0.943. The parameter estimates from the beef share equation show that beef's own-price, the price of poultry, and the price of pork are statistically significant at the 1% level. The expenditure variable also is significant at the 5% level. The health claim variable is statistically significant at the 10% level and indicates that the demand for beef was, on average, 1.3% greater after the approval of the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease" claim in 2000. The time trend for the beef share equation is statistically significant at the 10% level and indicates that beef demand has decreased on average by 0.19% per year.

The negative impacts of the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" health claim on pork demand was expected as health professionals have advised limiting the consumption of pork due to higher levels of saturated fats (e.g., American Heart Association 2017b). In contrast, the positive impacts of the health claim on beef was unexpected. However, there are a few reasons that could attribute to the increases in beef demand after 2000. First, while beef is higher in saturated fat, it also is a better source of other beneficial nutrients, such as iron (Dieticians of Canada 2016) and zinc (Dieticians of Canada 2017b). Elasticity estimates from previous research indicates that the positive impacts of information regarding the health benefits of iron, zinc, and protein (0.0248) outweighs the negative impacts of information about fat and cholesterol information (-0.023) on beef demand (Tonsor, Mintert and Schroeder 2010). In addition, there was a lot of consumer interest in low-carbohydrate diets (i.e., high protein diets) during the early 2000s (Tonsor, Mintert, and Schroeder 2010) that might also have contributed to the increase in beef demand after 2000.

As for changes over time, the positive changes in the consumption of poultry (0.587% per year) and negative changes in the consumption of pork (0.397% per year) and beef (0.19% per year) were as expected. These results suggest that over time consumers have adjusted their consumption of meats to include a higher portion of those lower in saturated fats (poultry) compared to the alternatives (pork and beef).

The elasticity estimates for the meat demand system are reported in Table 5. All own-price elasticities are negative and inelastic. The own-price elasticities are -0.494 for poultry, -0.525 for pork, and -0.162 for beef. Cross-price elasticities reveal that poultry, pork and beef are all weak complements to each other in all share equations. For example, all else equal, a 1% increase in the price of poultry is expected to decrease pork demand by 0.427% or decrease beef demand by 0.321%. Similarly, a 1% increase in the price of pork is expected to decrease poultry demand by 0.212% or decrease beef demand by 0.117%. Last, a 1% increase in the price of beef is expected to decrease poultry demand by 0.394% or pork demand by 0.361%. As for the expenditure elasticity, it reveals that all meats are normal goods, but poultry (1.100) and pork (1.313) are income elastic while beef (0.600) is considered income inelastic.

The inelastic own-prices are consistent with previous research for poultry, pork, and beef demand (e.g., Cranfield 2012; Tonsor, Mintert, and Schroeder 2010; Brester and Schroeder 1995). For example, Cranfield (2012) found own-price elasticities of -0.609 for poultry, -0.755 for pork, and -0.829 for beef in Canada. Tonsor, Mintert, and Schroeder (2010) found own-price elasticities of -0.609 for poultry, -0.755 for pork, and -0.829 for beef in the U.S. Brester and Schroeder (1995) found own-price elasticity estimates of -0.33 for poultry, -0.69 for pork, and -0.56 for beef in the U.S. In addition, there does not appear to be a consensus on price sensitivity among poultry, pork and beef and thus no expectations were made. For example, Cranfield (2012) found that, in Canada, beef has the greatest income elasticity (1.117) followed by pork (1.106) then poultry (0.642). Tonsor and Olynk (2011) found that in the U.S., poultry has the greatest income elasticity (0.3554) then beef (0.3392) and pork (0.1047).

Table 5. Elasticity Estimates - Meats in Canada

Independent Variables	**Share Equations**		
	Poultry	**Pork**	**Beef**
Poultry Price	-0.494***	-0.427***	-0.321***
	(0.063)	(0.126)	(0.082)
Pork Price	-0.212***	-0.525***	-0.117**
	(0.047)	(0.119)	(0.058)
Beef Price	-0.394***	-0.361***	-0.162**
	(0.050)	(0.097)	(0.073)
Expenditure	1.100***	1.313***	0.600***
	(0.103)	(0.177)	(0.165)

Standard errors reported in parentheses
Significance at *** 1%, ** 5%, * 10% level

Source: Author

In contrast, the gross complementary cross-price elasticities found here were at first surprising. However, they are consistent with the uncompensated cross price elasticities in Adhikari et al. (2006) and Taljaard, Alemu and Van Schalkwyk (2004). Adhikari et al. (2006) also found poultry, pork and beef to be gross complements to each other when using U.S. data from 1989 to 2003. They found uncompensated cross-price elasticities for the price of poultry with respect to pork demand is -0.276 and is -0.102 for beef demand. They also reported cross-price elasticities for the price of pork with respect to poultry demand of -0.135 and -0.114 for beef demand. Last, the cross-price elasticities for the price of beef with respect to poultry demand is -0.154 and is -0.378 for pork demand. The authors also divided the sample period into two sub periods and found that from 1989 to 1997, pork (0.10) and poultry (0.071) were weak substitutes only in the beef equation, and, from 1997 to 2003, only poultry was a weak substitute (0.094) in the pork equation. Their results suggest that the complementary relationship between meats might not be constant over time, but could depend on factors that differ across time.

Additionally, Taljaard, Alemu and Van Schalkwyk (2004) also found that chicken, pork, and beef are gross substitutes in South Africa from 1970 to 2000. The authors found that, in the beef equation, the cross-price elasticities for chicken and pork are -0.282 and -0.03, respectively. In the chicken equation, the cross-price elasticities for chicken and pork are -0.11 and -0.074, respectively. Last, in the pork share equation, the cross-price elasticities for beef and chicken are -0.074 and -0.454, respectively.

While the gross complementary relationship was not expected, after further consideration, it makes sense that consumers might not view them as substitutes for a couple reasons. First, each type of protein has significantly different nutrient profiles to offer. For example, beef is higher in beneficial nutrients such as vitamin B12 (Dietitians of Canada 2017a), zinc (Dietitians of Canada 2017b), and iron (Dietitians of Canada 2016) than are pork and poultry, but it is also considered higher in saturated fats (American Heart Association 2017b). As a result, consumers might want to consume poultry, pork, and beef in somewhat fixed proportions to ensure a balanced diet and, therefore, as the price of one type of meat increases, consumers might reduce the consumption of all meats to maintain that balance. Second, consumers might not view poultry, pork, and beef as substitutes based on differences in flavors across the meats.

5.4 The Demand for Fruits and Vegetables in Canada

The annual per capita consumption of fruits and vegetables in Canada has been gradually increasing since 1985. The annual per capita consumption of fresh fruits, preserved fruits, fresh vegetables, and preserved vegetables in Canada from 1985 to 2016 is shown in Figure 4. The graph shows an overall upward trend in the consumption of fresh fruits and fresh vegetables in Canada. However, after 2000, there was a decline in consumption of fresh vegetables until around 2007 when consumption increased again and then leveled off. In contrast, consumption of preserved fruits trended upwards until around 2000 when it began gradually declining thereafter. Preserved vegetables declined slightly over the period, but in general remained relatively more constant. Given the volume of published research on the benefits of fruits and vegetables consumption and media campaigns to encourage increased consumption (see Section 2.4 for more information), the increase in the per capita consumption of fruits and vegetables since 1985 is not surprising.

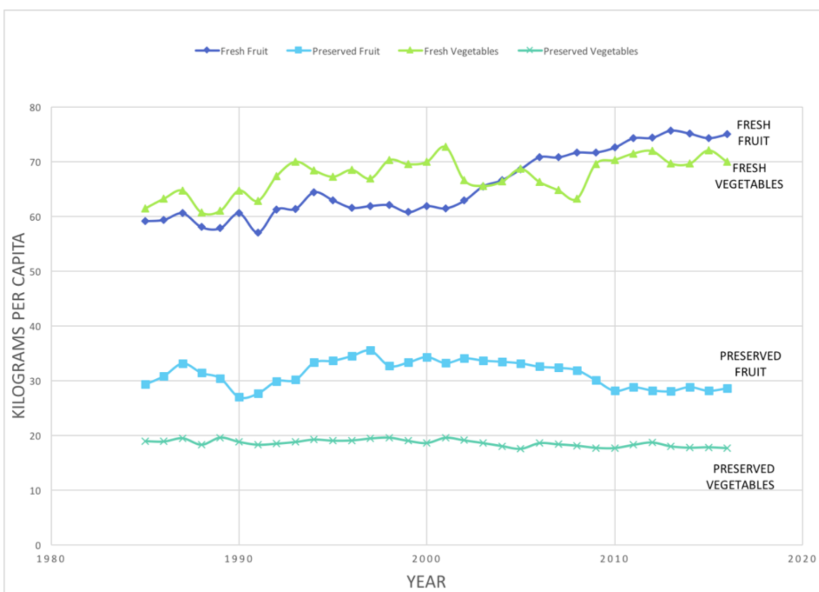

Figure 4. Consumption of Fruits and Vegetables in Canada, 1985 to 2016

Source: Statistics Canada (2017c)

The coefficient estimates for the demand for fruits and vegetables in Canada from 1985 to 2016 are in Table 6. The demand equation for fresh fruits has a R^2 of 0.717. The results show that for the fresh fruit equation, the prices of fresh fruit, fresh vegetables and preserved vegetables are statistically significant at the 1% level. In addition, the expenditure variable is significant at the 10% level. The health claim variable indicated that there were no significant impacts on fresh fruit demand after the approval of the “Fruits and Vegetables and Cancer” claim in 2000. The time trend also was not statistically significant.

The demand equation for preserved fruit has a R^2 of 0.795. The results show that the price variables are not statistically significant, but the expenditure variable is significant at the 1% level. The health claim variable is insignificant. The time trend is significant at the 1% level and indicates that, on average, the demand for preserved fruits increased by 0.4% per year.

The R^2 for the fresh vegetable equation is 0.694. The coefficient estimates for the price of fresh fruit, fresh vegetables, preserved vegetables, and expenditure variables are significant at the 1% and 5% levels. The health claim variable did not produce statistically significant results. However, the time trend is significant and indicates that, on average, there was a 0.3% decrease per year in the demand for fresh vegetables over the period.

Last, the R^2 for the preserved vegetable equation is 0.896. The price of fresh fruit, fresh vegetables, and preserved vegetables is significant at the 1% and 5% levels. The health claim variable did not have a significant impact on the demand for preserved vegetables. The time trend is significant at the 10% level and indicates that, on average, the demand for preserved fruit decreased by 1% per year over the sample period.

Table 6. Coefficient Estimates - Demand for Fruits and Vegetables in Canada

	Share Equation			
Independent Variables	**Fresh Fruit**	**Preserved Fruit**	**Fresh Vegetables**	**Preserved Vegetables**
Fresh Fruit Price	0.170***	0.011	-0.130***	-0.050***
	(-0.047)	(-0.030	(-0.037)	(-0.011)
Preserved Fruit Price	0.011	0.038	-0.039	-0.009
	(-0.030)	(-0.037	(-0.028)	(-0.021)
Fresh Vegetables Price	-0.130***	-0.039	0.197***	-0.027**
	(-0.037)	(-0.028	(-0.043)	(-0.012)
Preserved Vegetables Price	-0.050***	-0.009	-0.027**	0.087***
	(-0.011)	(-0.021	(-0.012)	(-0.021)
Expenditure	0.130*	-0.292***	0.164**	-0.002
	(-0.074)	(-0.064	(-0.071)	(-0.022)
HC2000	0.006	-0.002	-0.003	-0.001
	(-0.009)	(-0.007)	(-0.007)	(-0.002)
Time	-0.0003	0.004***	-0.003**	-0.001*
	(-0.001)	(-0.001)	(-0.001)	(0.000)
Constant	-0.720	2.538***	-0.945*	0.127
	(-0.591)	(-0.517)	(-0.566)	(-0.176)
Observations	32	32	32	32
R-squared	0.717	0.795	0.694	0.896

Standard errors reported in parentheses
Significance at *** 1%, ** 5%, * 10% level

Source: Author

It was expected that the "Fruits and Vegetables and Cancer (2000)" health claim would have positive impacts on the demand for fruits and vegetables. However, the lack of significance makes sense considering that recognized health organizations began promoting and educating consumers on the benefits of fruit and vegetable consumption in the early 1990s (see Section 2.4 for more information). This suggests that consumers might have started adjusting their consumption prior to the approval of this health claim. In addition, the absence of impacts of the health claim policy on the demand for the fresh fruits and fresh vegetables is not surprising as these items are typically found in the produce isle with limited packaging for health claims to be placed on.

In addition, the increase in the demand for preserved fruits (0.4% per year) and decrease in the demand for fresh vegetables (0.3% per year) over time also makes sense. Previous research has shown that changing dynamics in the household, such as more women entering the labour force, has contributed to an increased preference for convenience foods (Tonsor, Mintert, and Schroeder 2010). Harris and Shiptsova (2007) found that 91% of consumers purchase convenience foods due to less available time to prepare foods and that sales of prepared foods increased by 53% since 1987 to 2002. Thus, consumers might be purchasing more preserved fruits and less fresh vegetables over time due to changes in lifestyle.

The price and expenditure elasticities are reported in Table 7. The results show that own-price elasticities for fresh fruit (-0.650), preserved fruit (-0.504), fresh vegetables (-0.598), and preserved vegetables (-0.221) are all inelastic and negative. The cross-price elasticities in the fresh fruit share equation reveal preserved fruits (-0.037), fresh vegetables (-0.495) and preserved vegetables (-0.184) are complements. In the preserved fruit equation, fresh fruit (0.618), fresh vegetables (0.336) and preserved vegetables (0.126) are substitutes for fresh fruit. In the fresh vegetable equation, fresh fruits (-0.540), preserved fruits (-0.200), and preserved vegetables (-0.131) are complements. Last, in the preserved vegetable equation, fresh fruits (-0.444), preserved fruits (-0.082), and fresh vegetables (-0.238) are complements. Overall, there is a complementary relationship between fresh fruit, preserved fruit, fresh vegetables, and preserved vegetables except for in the preserved fruit share equation where fresh fruit, fresh vegetables, and preserved vegetables are substitutes. The expenditure elasticities indicate that fresh fruit (1.367), fresh vegetables (1.471) and preserved vegetables (0.985) are normal goods while preserved fruit (-0.575) is an inferior good.

The inelastic own-price sensitivity and complementary relationship between fruits and vegetables was expected as it is consistent with the results of previous related research. For example, Pomboza and Mbaga (2007) studied the demand for broad food categories in Canada in 2001 and found that own-price elasticities for fruits and vegetables were also inelastic, with fruits being slightly more price sensitive (-0.846) than vegetables (-0.651). The authors also found a complementary relationship between increases in the price of fruit and the demand for vegetables (-0.074) and vice versa (-0.063). In addition, Adhikari et al. (2007) also found inelastic own-price sensitivity in the demand for vegetables, specifically, tomatoes (-0.40), broccoli (-0.33), lettuce (-0.61), mushrooms (-0.79), and potatoes (-0.33) in the U.S. from 1980 to 2003.

Table 7. Elasticity Estimates - Fruits and Vegetables in Canada

	Share Equations			
Variables	**Fresh Fruit**	**Preserved Fruit**	**Fresh Vegetables**	**Preserved Vegetables**
Fresh Fruit Price	-0.650***	0.618***	-0.540***	-0.444***
	(0.146)	(0.160)	(0.149)	(0.120)
Preserved Fruit Price	-0.037	-0.504***	-0.200**	-0.082
	(0.096)	(0.170)	(0.104)	(0.203)
Fresh Vegetables Price	-0.495***	0.336***	-0.598***	-0.238**
	(0.109)	(0.128)	(0.174)	(0.126)
Preserved Vegetables Price	-0.184***	0.126*	-0.131***	-0.221
	(0.038)	(0.109)	(0.044)	(0.193)
Expenditures	1.367***	-0.575*	1.471***	0.985***
	(0.208)	(0.347)	(0.202)	(0.196)

Standard errors reported in parentheses
Significance at ***1%, **5%, and *10% levels

Source: Author

In contrast, previous research suggests income elasticity is dependent upon the specific type of fruit or vegetable and thus it is hard to make expectations for such broad categories as “fresh” or “preserved” fruits and vegetables. For example, Adhikari et al. (2007) found that fresh vegetables are normal goods, but whether they are income elastic (2.16 for broccoli and 1.34 for lettuce) or inelastic (0.57 for mushrooms) depends on the specific vegetable. The negative income elasticity for preserved fruits indicates they are not as desirable as fresh fruits and, as income increases, consumers would rather allocate more money to fresh products than preserved.

5.5 The Demand for Fats in the United States

The annual per capita consumption of fats in the United States from 1984 to 2010 is shown in Figure 5. The figure reveals that annual per capita consumption of margarine has steadily declined while butter and lard also have declined but remained relatively more constant over the period. As in Canada, the trends in fat consumption pictured in Figure 5 are not surprising given the increased understanding of the negative health consequences of saturated and trans fats since the 1980s (see Section 2.4 for more information).

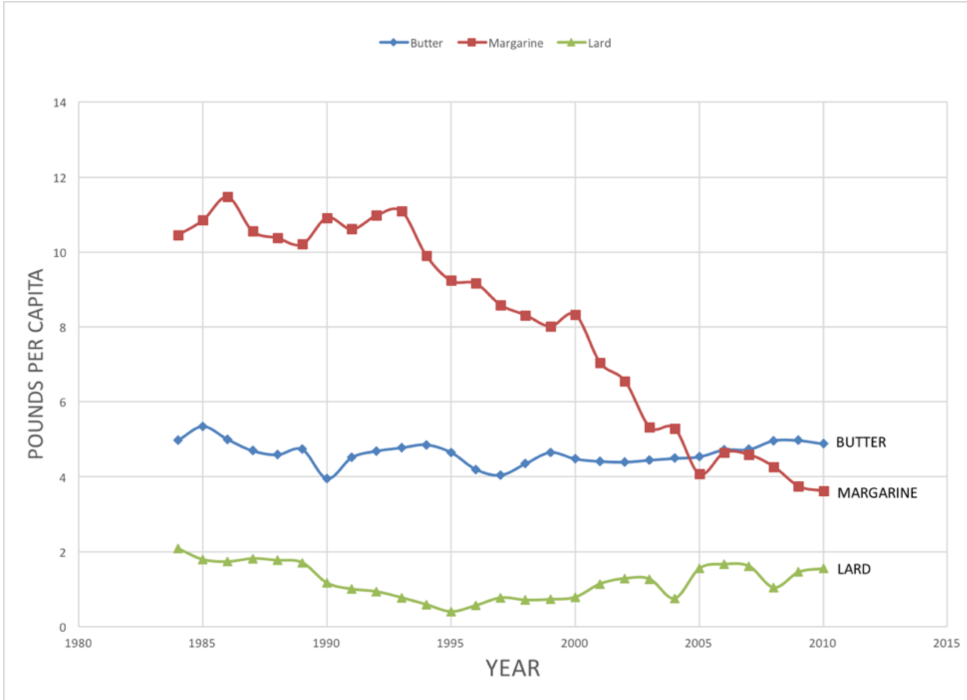

Figure 5. Per Capita Consumption of Fats in the U.S., 1984 to 2010

Source: ERS (2017a).

The coefficient estimates for the demand for fats in the U.S. from 1984 to 2010 are shown in Table 8. The share equation for butter has an R^2 of 0.947. The results for the butter share equation show that butter's own-price and the price of margarine statistically significant at the 1% level. The health claim variable is significant at the 1% level and indicates that, on average, the demand for butter was 7.1% lower after the approval of the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" claim in 1993. In addition, the time trend is significant at the 1% level and indicates that the demand for butter has increased an average of 1.31% per year over the sample period.

Next, the share equation for margarine has an R^2 of 0.94. The results show that the price of margarine, butter, and lard are significant at the 1% and 5% levels. In addition, the health claim variable is significant at the 1% level and indicates that, on average, the demand for margarine was 8.50% greater after the approval of the health claim in 1993. The time trend is also significant at the 1% level and indicates that margarine demand fell by an average of 1.38% per year over the sample period.

Table 8. Coefficient Estimates - Demand for Fats in the U.S.

Independent Variables	Share Equation		
	Butter	**Margarine**	**Lard**
Butter Price	0.244***	-0.243***	-0.001
	(-0.028)	(-0.030)	(-0.003)
Margarine Price	-0.243***	0.253***	-0.010**
	(-0.030)	(-0.033)	(-0.004)
Lard Price	-0.001	-0.010**	0.011***
	(-0.003)	(-0.004)	(-0.002)
Expenditure	-0.079	0.083	-0.004
	(-0.152)	(-0.167)	(-0.019)
HC1993	-0.0710***	0.0850***	-0.0141***
	(-0.026)	(-0.029)	(-0.003)
Time	0.0131***	-0.0138***	0.00073***
	(-0.002)	(-0.002)	(-0.0002)
Constant	0.566	0.387	0.047
	(-0.681)	(-0.746)	(-0.086)
Observations	27	27	27
R-squared	0.947	0.94	0.656

Standard errors reported in parentheses
Significance at *** 1%, ** 5%, * 10% level

Source: Author

Last, the share equation for lard has an R^2 of 0.656. The results from the lard equation show that the price of lard and margarine are significant at the 1% level. The health claim variable is also significant at the 5% level and indicates that the demand for lard was on average 1.41% lower after the approval of the health claim in 1993. In addition, the time trend is significant at the 1% level and indicates that the demand for lard increased by approximately 0.073% per year over the sample period.

The results of the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" health claim on the demand for butter, margarine, and lard in the U.S. were as expected. After the approval in 1993, the demand for butter decreased (7.1%), the demand for margarine increased (8.50%), and the demand for lard decreased (1.41%). The "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" health claim describes the adverse health effects of saturated fats on cholesterol and the risk of heart disease. Therefore, it makes sense that consumers would respond to this type of health information by decreasing the demand for butter and lard, which are high in saturated fats. In addition, during the early 1990s, there was considerable published research and media attention about the link between saturated fats and heart disease (see Section 2.4 for more information) that could have contributed to the success of this health claim.

The positive impacts on the demand for margarine after the approval of the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" also make sense. During the 1980s and 1990s, manufacturers increasingly used trans fats as a replacement for saturated fats in margarine to make them a lower saturated fat alternative (see Section 2.4 for more information). While trans fats are now known to have significant adverse effects on health, the health implications of trans fats were not yet fully understood at the time of approval of the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" health claim. Therefore, it makes sense that, in 1993, consumers would respond to advice about saturated fats with an increase in the demand of an alternative lower saturated fat option, in this case, margarine.

In addition, the results from the trend variables also make sense. It appears that consumers have adjusted their demand for butter (1.31% increase per year), margarine (1.38% decrease per year), and lard (0.073% increase per year) over the whole sample period to reflect the significant changes in the understanding of the role of different dietary fats on health. Specifically, the realization that trans fats have even more severe health consequences than saturated fats (see Section 2.4 for more information) is captured by the decrease in margarine demand over time. The increase in butter and lard demand over time might capture that once there was more understanding about trans fats, consumers might have reverted to consuming butter.

Some comparisons of the impact of health claims on the demand for margarine and butter in the U.S. can also be made with the results from the Canadian fats and oils demand system in Section 5.2. The approval of the Canadian "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease" health claim in 2000 resulted in a 3.83% decrease in the demand for margarine and did not have a significant impact on butter demand in Canada. In contrast, the approval of the similar "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" health claim in the U.S. in 1993 increased margarine demand (8.50%) and decreased butter demand (7.1%) in the U.S. The differences of the impacts of similar U.S. and Canadian claims on butter and margarine likely reflect the differences in knowledge and understanding about the role of saturated fats and trans fats in 1993 versus 2000 (see Section 2.4 for more information). Additionally, the Canadian results also showed significant changes over time consistent with those in the U.S. In that regard, margarine consumption in Canada also decreased over time (0.53% per year) although not to the same extent as in the U.S. (1.38% per year). Again, the decline in margarine consumption over time is likely a reflection of cumulative changes in health information over the same period.

The elasticity estimates for the demand for fats in the U.S. are presented in Table 9. The own-price elasticities for butter (-0.487), margarine (-0.489), and lard (-0.104) are all negative and inelastic. In addition, the cross-price elasticities for the price of margarine with respect to butter demand (-0.373) and vice versa (-0.680) indicates a complementary relationship. In the margarine share equation, the cross-price elasticities for the price of lard is -0.025, also indicating a complementary relationship. In the lard share equation, cross-price elasticities indicate butter (0.105) is a substitute for lard and margarine (-0.676) is a complement for lard. Last, the expenditure elasticities indicate that butter (0.860), margarine (1.194), and lard (0.679) are normal goods with margarine slightly income elastic and butter and lard slightly income inelastic.

Table 9. Elasticity Estimates - Fats in the U.S.

	Share Equation		
	Butter	**Margarine**	**Lard**
Butter Price	-0.487***	-0.680***	0.105
	(0.129)	(0.265)	(0.947)
Margarine Price	-0.373***	-0.489**	-0.676
	(0.090)	(0.222)	(1.074)
Lard Price	0.0001	-0.025**	-0.104
	(0.007)	(0.011)	(0.181)
Expenditure	0.860***	1.194***	0.679
	(0.270)	(0.392)	(1.585)

Standard errors reported in parentheses
Significance at ***1%, **5%, and *10% levels

Source: Author

The inelastic own-price elasticities and expenditure elasticities were not surprising as they are consistent with previous findings in the literature. In that regard, like the results presented here, Chang and Kinnucan (1991) also found inelastic own-prices for butter (-0.74), margarine (-0.09), and shortening (-0.29). Goddard and Amuah (1989) also found butter to be income elastic (1.18) and margarine to be income inelastic (0.84). Goddard and Amuah (1989) also found an overall complementary relationship between butter and margarine (cross-price elasticities of -0.26 and -0.29) using uncompensated price elasticities. The complementary relationship between butter and margarine was somewhat unexpected. However, it might reflect different nutritional properties, consistencies, and flavors between butter and margarine that might contribute to reasons why they are not viewed as appropriate substitutes for each other.

In addition, there are both some consistencies and differences between the U.S. estimates presented here and Canadian elasticity estimates found in Section 5.2. In that regard, like the U.S., the Canadian results also showed inelastic own-prices for butter (-0.359) and margarine (-0.505) As for differences, the Canadian results indicated that butter and margarine were substitutes whereas they were found to be complements in the U.S. The difference in cross-price elasticities between butter and margarine might reflect differences in consumer tastes, preferences, and cultures in Canada versus the U.S.

5.6 The Demand for Meat in the United States

Like Canada, the annual per capita consumption of poultry, pork and beef in the U.S. has changed significantly since the 1970s. The annual per capita consumption of poultry, pork and beef in the U.S. from 1970 to 2016 is shown in Figure 6. The graph reveals that poultry consumption has increased significantly since 1970 while beef consumption has declined. In contrast, pork consumption has remained relatively more constant compared to poultry and beef consumption. Again, these results make sense given the changes in the understanding of dietary fats and health that occurred over the period.

The coefficient estimates for the demand for meats in the U.S. from 1970 to 2016 are shown in Table 10. The poultry share equation has an R^2 of 0.966. The results for the poultry share equation indicate that the price of poultry, pork, and beef and the expenditure variable are significant at the 1% level. The health claim variable is statistically significant at the 5% level and indicates that the demand for poultry was, on average, 1.95% greater after the approval of the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" health claim in 1993.

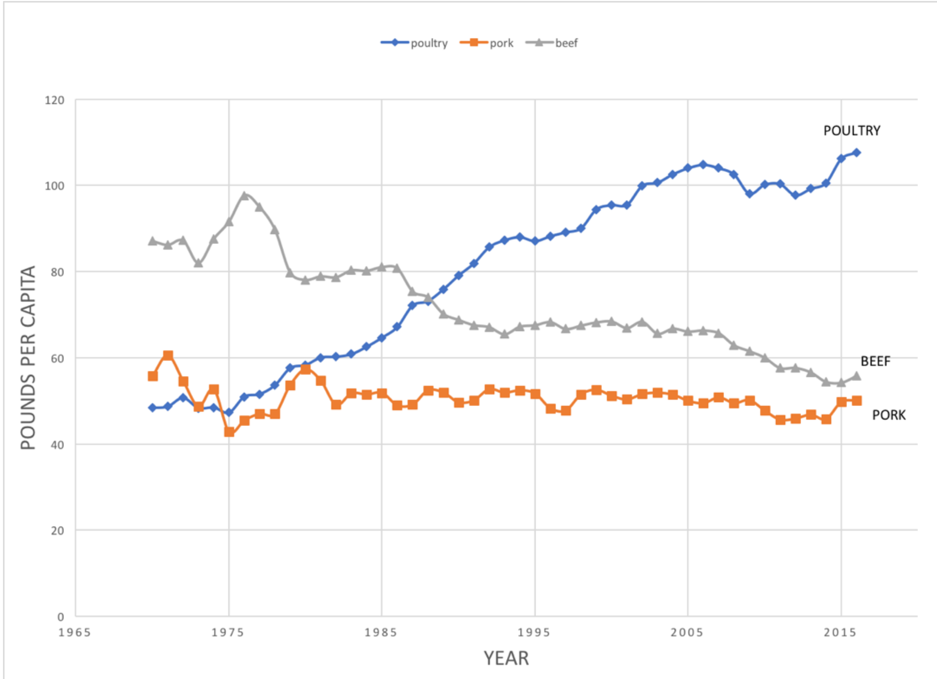

Figure 6. Consumption of Meats in the U.S., 1970 to 2016

Source: ERS (2017b)

The R^2 for the pork share equation is 0.947. The results from the pork share equation show that pork's own-price and the price of poultry are statistically significant at the 1% level. In addition, the time trend is significant at the 1% level and indicates that, on average, the demand for pork decreased by 0.24% per year over the sample period.

The R^2 for the beef share equation is 0.905. The results from the beef share equation show that beef's own-price, the price of poultry, and the expenditure variable significant at the 1% level. Additionally, the health claim variable in the beef share equation is significant at the 5% level and indicates that after the approval of the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" health claim in 1993 the demand for beef was, on average, 2.42% lower than before the approval.

The impacts of the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" health claim on poultry (1.95% increase) and beef (2.42% decrease) demand were as expected and make sense considering poultry is a relatively low source of saturated fats and beef is relatively a higher source (American Heart Association 2017a). In addition, there was a large volume of published research on the impacts of saturated fats and related media attention around the time of this claim (Wasink and Cheney 2005) that likely contributed to the success of this health claim in terms of reducing the consumption of foods higher in saturated fats.

Table 10. Coefficient Estimates - Demand for Meats in the U.S.

	Share Equation		
Independent Variables	**Poultry**	**Pork**	**Beef**
Poultry Price			
	(-0.027)	(-0.015)	(-0.026)
Pork Price	-0.052***	0.050***	0.002
	(-0.015)	(-0.012)	(-0.010)
Beef Price	-0.164***	0.002	0.162***
	(-0.026)	(-0.010)	(-0.031)
Expenditure	0.148***	0.018	-0.166***
	(-0.030)	(-0.013)	(-0.036)
HC1993	0.0195**	0.0047	-0.0242**
	(-0.009)	(-0.004)	(-0.011)
Time	0.0014	-0.0024***	0.001
	(-0.001)	(-0.0004)	(-0.001)
Constant	-0.924***	0.146	1.779***
	(-0.238)	(-0.103)	(-0.285)
Observations	47	47	47
R-squared	0.966	0.947	0.905

Standard errors reported in parentheses
Significance at *** 1%, ** 5%, * 10% level

Source: Author

In contrast to the U.S. meat demand, the results from the Canadian meat demand system in Section 5.3 showed positive impacts on beef demand (1.3%) from the approval of a similar Canadian health claim in 2000. As discussed in Section 5.3, the opposite impacts on beef demand in Canada compared to the U.S. from the approval of substantially similar health claims is likely a result of the timing of the health claims and the different health trends, such low-carb diets, that were occurring in 2000 versus 1993.

The price and expenditure elasticity estimates are reported in Table 11. All own-price elasticities are negative and inelastic for poultry (-0.606), pork (-0.813), and beef (-0.383). As for the cross-price elasticities, in the poultry equation, pork (-0.220) and beef (-0.545) are complements. In the pork equation, poultry (-0.243) and beef are complements (-0.019). In the beef equation, poultry (-0.273) is a complement and pork (0.118) is a substitute. To summarize the cross-price elasticities, poultry, pork, and beef are all complements to each other except for pork which is a substitute in the beef share equation. As for the expenditure elasticities, all are positive indicating poultry (1.372), pork (1.075), and beef (0.538) are normal goods in the U.S. and that poultry and pork are income elastic while beef is income inelastic.

Table 11. Elasticity Estimates - Meats in the U.S.

	Share Equation		
Variables	**Poultry**	**Pork**	**Beef**
Poultry Price	-0.606***	-0.243***	-0.273***
	(0.074)	(0.074)	(0.079)
Pork Price	-0.220***	-0.813***	0.118***
	(0.040)	(0.056)	(0.037)
Beef Price	-0.545***	-0.019	-0.383***
	(0.073)	(0.053)	(0.089)
Expenditure	1.372***	1.075***	0.538***
	(0.076)	(0.054)	(0.101)

Standard errors reported in parentheses
Significance at ***1%, **5%, and *10% levels

Source: Author

The elasticity estimates found in this study are not surprising. The literature typically reports inelastic own-prices and, although there does not appear to be a consensus on which meats are substitutes, the literature typically finds that at least one meat is a substitute to another. In that regard, consistent with the results found here, Brester and Schroeder (1995) also found that poultry (-0.33), pork (-0.69), and beef (-0.56) are own-price inelastic in the U.S. from 1970 to 1993 and that pork shows the greatest own-price sensitivity relative to poultry and beef. Similarly, Tonsor, Mintert and Schroeder (2010) found poultry (-0.099), pork (-0.7396), and beef (-0.4199) are own-price inelastic and that pork is most sensitive to own-prices in the U.S. from 1982 to 2007. Further, the results from the Canadian estimation in Section 5.3 also show poultry (-0.494), pork (-0.525), and beef (-0.162) are own-price inelastic and that pork has the greatest own-price sensitivity.

In addition, like the results presented here, Tonsor, Mintert and Scheoder (2010) also found that poultry and beef are gross complements. The cross-price elasticities for the price of poultry on beef demand is -0.0406 and the price of beef on poultry demand is -0.1113. Similarly, Kinnucan, Xiao, Hsia and Jackson (1997) also found that pork and poultry are complements in the U.S. from 1976 to 1993. Further, the Canadian estimates presented in Section 5.3 also show that poultry and beef are complements. In contrast to the U.S. results presented here, Tonsor, Mintert and Scheoder (2010) found that pork and beef are gross substitutes (0.0163 and 0.0269) while the results here show that beef is only a substitute only in the pork equation but not vice versa.

The fact that U.S. consumers were found to allocate more expenditures towards poultry (1.372) than pork (1.075) and beef (0.538) makes sense because of the negative health aspects of consuming too much red meat due to higher saturated fat and cholesterol levels. In addition, previous research has found similar income elasticities. Adhikari et al. (2006)

also found that poultry (1.020) and pork (1.880) are income elastic and that beef (0.404) is income inelastic in the U.S. using data from 1989 to 2003. In addition, Kinnucan, Xiao, Hsia and Jackson (1997) found that pork is income elastic (1.005) and beef is income inelastic (0.999) in the U.S. from 1976 to 1993.

5.7 Population Health Status

5.7.1 Male Life Expectancy at Age 65

The factors that contribute to male life expectancy at age 65 are shown under Model 1 (inclusion of trend variable) and Model 2 (inclusion of trend and health claim variables) in Table 12. A discussion of the results from Model 1 is provided first followed by a discussion of the results from Model 2. Model 1 shows the factors that contribute to male life expectancy at age 65 in North America over 1990 to 2010. The Wald chi-squared test statistic of 6095.22 and a p-value of 0.00 indicates that the variables in Model 1 are jointly significant at the 1% level.

The changes in male health status over time are presented in Model 1. The results show that the impacts of tobacco (ln(SMOKE)), alcohol (ln(DRINK)), fruit and vegetable (ln(FV)), and fat (ln(FAT)) consumption on health outcomes are statistically significant at the 1% and 10% levels. The elasticity estimates indicate that tobacco consumption (-0.0508) and fat consumption (-0.0480) have negative impacts on male life expectancy at age 65. In contrast, alcohol consumption (0.145) and fruit and vegetable consumption (0.0442) have positive impacts on male life expectancy at age 65. For example, the coefficient on fat consumption (ln(FAT)) indicates that a 1% increase in the consumption of fat would lead to a 0.048% decrease in male life expectancy at age 65, all else equal. The coefficient on ln(FV) indicates that a 1% increase in the consumption of fruits and vegetables would lead to a 0.0442% increase in male life expectancy at age 65.

The findings that tobacco negatively impacts health and fruit and vegetables positively impacts health is not surprising. It is now widely recognized that tobacco consumption has serious negative health consequences such as an increased risk of lung cancer, stroke and heart disease (CDC 2017b; WHO 2017a). Similarly, beneficial effects of fruit and vegetable consumption also have been well-known by health professionals (e.g., Health Canada 2000). Further, the impacts of tobacco and fruit and vegetables are consistent with previous findings in the literature on health production functions. Like the results presented here, elasticity estimates from Cremieux, Oulette and Pilon (1999) showed that tobacco consumption decreases male life expectancy at birth (-0.018). Similarly, Shaw, Horrace, and Vogel (2000) also found that tobacco consumption decreases population life expectancy at age 40 (-0.067). Further, Shaw, Horrace, and Vogel found similar positive impacts of fruit and vegetable consumption on male life expectancy at age 40 (0.140).

In contrast, the impacts of fat consumption on health outcomes are not as clear in the literature. Consistent with the results here, Berger and Messer (2002) also found negative impacts of fat consumption on health. Specifically, Berger and Messer (2002) also found that a 1% increase in fat consumption caused a 0.015% increase in mortality rates in OECD countries. Similarly, Cremieux, Oulette and Pilon (1999) also that a 1% increase in spending on fats is expected to increase male infant mortality rates by 0.242% and decrease male life expectancy by 0.005%. In contrast to the results shown here, elasticity estimates from Shaw, Horrace and Vogel (2005) showed that fat consumption increases life expectancy (0.022). Similarly, elasticity estimates from Miller and Frech (2000) also indicated that fat consumption increase life expectancy at age 60 (0.9096). The inconsistent effects of fat consumption on health is not that surprising. As discussed in Section 2.4, fat is essential to help the body function, but the beneficial effects of fat consumption are dependent upon which types of fats are being consumed. Therefore, the mixed results make sense as fats can have both beneficial and adverse impacts on health.

As for the socioeconomic factors in Model 1, GDP (ln(GDP)) and availability of healthcare resources (ln(DOCTOR)) are not significant in explaining male health status. Initially, education was also included as a factor, but due to high collinearity between education and GDP per capita and a reduction in statistical significance, education was omitted from regression. The insignificance of GDP and healthcare resources is unexpected as they are typically found to be quite significant in the literature (e.g., Filmer and Pritchett 1999; Or 2001; Thornton 2002; Berger and Messer 2002). However, the literature typically analyzes data on many diverse OECD countries and the lack of significance could be because the impacts of income in developed countries (Canada and the U.S.) are captured in some of the other variables, such as through improved diet or money to spend on tobacco and alcohol consumption.

The estimated coefficient estimation on pollution (ln(POL)) is statistically significant at the 1% level and indicates that a 1% increase in NO_x emissions per capita would lead to a 0.0322% decrease in male life expectancy. This result also is not surprising given that air pollution can cause serious respiratory and cardiovascular problems (Mackie and Rodriguez 2016). The coefficient on the Canada dummy also is statistically significant at the 1% level and indicates that male life expectancy is greater in Canada than the U.S. This result was expected as life expectancy over the sample period has in fact been higher in Canada than the U.S. (OECD 2016).

Last, the time trend (Time) is statistically significant at the 1% level and indicates that male life expectancy has been increasing by 0.6% per year over the sample period. This result is not unexpected considering that over the sample period there have been improvements in both medical practices and the understanding of the impacts of nutrition on health, which is now recognized to play a significant role in maintaining health and mitigating disease (WHO 2014).

Table 12. Determinants of Male Life Expectancy

	Model 1	Model 2
Independent Variables	**lnLE65_M**	**lnLE65_M**
ln(SMOKE)	-0.0508***	-0.0586***
	(-0.0084)	(-0.0093)
ln(DRINK)	0.145***	0.127***
	(-0.0274)	(-0.0287)
ln(FV)	0.0442*	0.0762**
	(-0.025)	(-0.0359)
ln(FAT)	-0.0480*	-0.0830**
	(-0.0291)	(-0.0363)
ln(DOCTOR)	0.051	0.0103
	(-0.0383)	(-0.0442)
ln(GDP)	-0.00957	0.00132
	(-0.0342)	(-0.0365)
ln(POL)	-0.0322**	-0.0353**
	(-0.0151)	(-0.016)
CANADA	0.172***	0.151***
	(-0.0185)	(-0.0218)
Time	0.00611***	0.00543***
	(-0.0011)	(-0.0011)
ln(FAT)*HC2000		0.0695
		(-0.0487)
ln(FV)*HC2000		-0.0496
		(-0.0351)
Constant	2.800***	2.814***
	(-0.222)	(-0.262)
Observations	34	34
Number of countries	2	2

Standard errors in parentheses
Significance at ***1%, **5%, and *10% level

Source: Author

Notes:
These models use pooled Canadian and U.S. data from 1990 to 2011. Due to limited data availability, the impacts of the U.S. health claim approved in 1993 could not be evaluated.

Model 2 is the same as Model 1 but with the inclusion of two interaction terms (ln(FV)*HC2000 and ln(FAT)*HC2000) that capture the impacts of the approval of the Canadian health claims in 2000 on the consumption of fruits and vegetables (ln(FV)*HC2000) and the consumption of fats (ln(FAT)*HC2000) (see Section 4.3 for more information). The results from Model 2 are shown in Table 12.

Like Model 1, the results show that all the same variables from the first model are significant in this model as well. Neither of the coefficients on the interaction terms (ln(FV)*HC2000 and ln(FAT)*HC2000) are significant suggesting that the health claim policy did not significantly affect consumption patterns for males. However, the time trend is statistically significant at the 1% level and indicates that male health status has improved, on average, by 0.534% per year over the sample period. The results from Model 2 suggest that males are not receptive to health claims, but instead make use of other resources to gather health information, such as doctors, family, or media, that facilitate improvements to their diets and health over time.

5.7.2 Female Life Expectancy at Age 65

The factors that contribute to female life expectancy at age 65 are shown under Model 3 (inclusion of time trend variable) and Model 4 (inclusion of time trend and health claim variables) in Table 13. A discussion of the results from Model 3 is provided first followed by the results from Model 4. First, the results from Model 3 show that factors that contribute to changes in female life expectancy at age 65 over time. A Wald test statistic of 1945.95 and p-value of 0.00 indicates that the variables in Model 3 are jointly significant at the 1% level. Like Model 1, tobacco consumption (ln(SMOKE)) is statistically significant at the 1% level and indicates a 0.051% decrease in female health for a 1% increase in tobacco consumption. Alcohol consumption is also significant at the 1% level and indicates a

0.145% increase in female health for a 1% increase in alcohol consumption. As was previously discussed for the impacts of lifestyle factors on male life expectancy, these impacts are not surprising given the results typically found in the literature (e.g Cremieux, Oulette and Pilon 1999; Shaw, Horrace, and Vogel 2000; CDC 2017b; WHO 2017a).

Table 13. Determinants of Female Life Expectancy at Age 65

	Model 3	**Model 4**
Variables	**lnLE65_F**	**lnLE65_F**
ln(SMOKE)	-0.0497***	-0.0585***
	(-0.0096)	(-0.0097)
ln(DRINK)	0.0691***	0.0635***
	(-0.0187)	(-0.021)
ln(FV)	0.0302	0.0809**
	(-0.0295)	(-0.0359)
ln(FAT)	-0.0328	-0.0574*
	(-0.0321)	(-0.0324)
ln(DOCTOR)	-0.108	-0.125
	(-0.0749)	(-0.0774)
EDUCATION	-0.00183	-0.00142
	(-0.0013)	(-0.0015)
ln(POL)	-0.0448*	-0.0526**
	(-0.0269)	(-0.0268)
CANADA	0.0929***	0.0675***
	(-0.0203)	(-0.0225)
Time	0.00303*	0.00183
	(-0.00182)	(-0.0019)
ln(FAT)*HC2000		0.0851*
		(-0.0455)
ln(FV)*HC2000		-0.0610*
		(-0.0329)
Constant	3.498***	3.443***
	(-0.189)	(-0.207)
Observations	34	34
Number of country	2	2

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author

These models use pooled Canadian and U.S. data from 1990 to 2011. Due to limited data availability, the impacts of the U.S. health claim approved in 1993 could not be evaluated.

A high correlation between GDP and education resulted in GDP being omitted from the regressions. However, neither GDP nor education were significant in either case. Similar to the impacts on male life expectancy, pollution is found to negatively affect female health. The coefficient on the pollution variable (ln(POL)) indicates that a 1% increase in NO_x emissions is expected to decrease female life expectancy by 0.0448%. This finding was expected as it is consistent with previous findings like Joumard et al. 2008 who found pollution decreases female life expectancy by 0.037%.

Like male life expectancy, the coefficient on CANADA indicates that female life expectancy is greater in Canada than the United States. As previously discussed, life expectancy has in fact been greater in Canada than the U.S. during the sample period (OECD 2016).

Additionally, Model 4 evaluates the impacts of the approval of the Canadian health claims in 2000 on female life expectancy at age 65. Model 4 is the same as Model 3 but includes two interaction terms that capture the impacts of the change in health claim policy in 2000 on fruit and vegetable consumption (ln(FV)*HC2000) and fat consumption (ln(FAT)*HC2000) (see Section 4.3 for more information). Due to limited data availability, the impacts of the U.S. health claim policy in 1993 could not be evaluated. A Wald chi-squared test statistic of 2167 and p-value of 0.00 indicates that the variables in Model 4 are jointly significant at the 1% level.

Like the results on female life expectancy found in Model 3, tobacco consumption is expected to decrease female life expectancy (-0.0585) and alcohol consumption (0.0635) is expected to increase female life expectancy. Again, these results are similar to those for male life expectancy at age 65. The fruits and vegetables variable (ln(FV)) is significant at the 5% level and the interaction term that accounts for the impacts of the health claim policy in 2000 on fruit and vegetable consumption (ln(FV)*HC2000) is significant at the 10% level. These variables indicate that, prior to the approval of the health claims in 2000, a 1% increase in fruits and vegetable consumption (ln(FV)) was expected to increase life female expectancy by 0.0809%, all else equal. To find the impacts of fruit and vegetable consumption on health after the approval of the health claim, the additional impact of the interaction term is also considered (ln(FV) plus ln(FV)*HC2000). These results show that, after the approval of the health claims in 2000, a 1% increase in fruit and vegetable consumption is expected to increase female life expectancy by 0.0199%, all else equal. The smaller impact of fruit and vegetable consumption after the approval of the health claim might reflect decreasing marginal returns to fruit and vegetable consumption. In Canada, it is likely that the largest marginal benefits of fruit and vegetable consumption on health already have been realized on average.

The fat consumption variable (ln(FAT)) and the interaction term that accounts for the impacts of the health claim policy in 2000 on fat consumption (ln(FAT)*HC2000) are significant at the 10% level. These variables indicate that, prior to the approval of the health claims in 2000, fat consumption (lnFAT) was expected to decrease life expectancy by 0.0574%, all else equal. Accounting for the impacts of the health claim policy in 2000 (ln(FAT) plus ln(FAT)*HC2000), a 1% increase in fat consumption is expected to increase female life expectancy at age 65 by 0.0277%, all else equal.

As discussed in Section 5.7.1, the positive impacts of fat consumption on female life expectancy are not surprising given the mixed results in the literature (e.g Berger and Messer 2002; Cremieux, Oulette and Pilon 1999; Shaw, Horrace and Vogel 2005; Miller and Frech 2000). In addition, the results from the fats and oils demand analysis revealed that consumption patterns of fats and oils in both Canada and the United States have changed significantly over the last 35 years (see Section 5.2 and 5.5 for more information). Interestingly, the impacts of the health claim variables were significant for females but not males. The positive impacts of fat consumption (0.0277%) on female life expectancy after the approval of the health claims might reflect changes in the types of fats being consumed (e.g., less saturated fats and more mono- and polyunsaturated fats) that have contributed to improved female health. In addition, it suggests that perhaps females are more attentive to health claims when making purchasing decisions than are males. Previous research on consumer attitudes and acceptance of functional foods also has found that females are more receptive to functional foods (e.g., Herath, Cranfield, and Henson 2008).

5.8 Summary of Empirical Results

The empirical results from this chapter indicate that health claim policies have been effective at influencing the demand for foods in Canada and the U.S. and that improvements in dietary patterns have coincided with better health outcomes in North America. The results from the Canadian demand analysis show that the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" health claim was successful at reducing the consumption of foods higher in saturated and trans fats. Specifically, the statistically significant results presented in this chapter indicated that demand for margarine (which was higher in trans fats around the time of approval) was found to decrease by 3.83% while pork demand decreased by 1.4% after the approval of the health claim. In contrast, the "Fruits, Vegetables and Cancer (2000)" health claim did not significantly affect the demand for fruits and vegetables in Canada. The lack of significance of the "Fruits, Vegetables and Cancer (2000)" health claim might be due to packaging constraints that limit the ability to place health claims on fresh produce. In addition, educational campaigns such as the "5 A Day" (see Section 2.4 for more information) might have motivated consumers to begin changing consumption patterns before this claim was approved.

Further, the results showed that Canadian consumers have been adjusting their consumption patterns towards healthier foods over time. On average, the demand for butter (0.25%), margarine (0.53%), pork (0.397%), beef (0.19%) decreased each year over the period while the demand for salad oils (0.77%), poultry (0.59%), and preserved fruit (0.4%) increased each year in Canada. The changes over time likely represent the effects of increasing related published research, media attention, and educational campaigns about dietary fats and fruits and vegetables that occurred over the sample period.

The Canadian demand analysis also provided insights into price and expenditure effects for fats and oils, meats, and fruits and vegetables demand. Specifically, butter (-0.359), margarine (-0.505), and salad oils (-0.269) were found to be own-price inelastic, which is consistent with previous findings. Further, butter and margarine were found to be gross substitutes while butter and salad oils and margarine and salad oils were found to be gross complements, which was consistent with findings in similar studies. Consistent with the literature, income elasticities were found to be greatest for salad oils (1.357) and weakest for butter (0.361). In addition, poultry (-0.494), pork (-0.525), and beef (-0.162) were found to be own-price inelastic and gross complements to each other. Inelastic own-prices for meats are consistent with previous findings whereas cross-price elasticities for meats tend to vary considerably across studies. The results also showed that pork (1.313) was most sensitive to income followed by poultry (1.100) then beef (0.600). As for fruits and vegetables, fresh fruit (-0.650), preserved fruit (-0.504), fresh vegetables (-0.598), and preserved vegetables (-0.221) were found to be own-price inelastic, which is consistent with the literature.

Further, consistent with previous findings, fruits and vegetables were found to be complements except for fresh fruit, fresh vegetables, and preserved vegetables were found to be substitutes in the preserved fruits share equation. The complementary relationship between fruits and vegetables makes sense given their different flavor profiles and uses in cooking, for example, desserts versus savory dishes. In contrast, it might be the case that preserved fruit are more often used in cooking applications where there are more savory and sweet variations of the same dish, for example, scones, pies or tarts.

Similarly, the results from the U.S. demand analysis showed that the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" health claim was successful at influencing the consumption of a healthier diet in the U.S. Specifically, statistically significant findings in this chapter indicate that the demand for butter (7.10%), lard (1.41%), and beef (2.42%), which have relatively higher sources of saturated fats, decreased after the approval of the health claim in 1993. In contrast, the demand for margarine (8.50%), which was thought to be a better option during the early 1990s because of reduced saturated fat contents, and poultry (1.95%) increased after the approval of the U.S. health claim in 1993. In addition, consumers showed significant changes in consumption patterns over time. The demand for pork fell on average by 0.24% and, consistent with the findings that TFAs have serious health consequences, the demand for margarine showed the largest annual decrease of 1.38% per year. The demand for butter (1.31%) and lard (0.073%) increased slightly over the period, which might also reflect changes due to the increased knowledge of the impacts of TFA consumption.

Additionally, the U.S. demand analysis revealed important price and expenditure effects. Own-price elasticities for butter (-0.487), margarine (-0.489), and lard (-0.104) were inelastic and consistent with previous findings. In contrast to the Canadian results, butter and margarine in the U.S. were found to be gross complements, which also has previously been found in some of the literature, and margarine was found to be income elastic (1.194). These differences might reflect different tastes, preferences, and cultures across the two countries. Butter (0.860), consistent with the Canadian findings, and lard were found to be income inelastic (0.679). As for meats, poultry (-0.606), pork (-0.813), and beef (-0.383) were found to be income inelastic in the U.S., which was consistent with previous literature, and all meats were found to be gross complements. Like the findings in this study, a small number of previous findings also have shown gross complementary relationships between poultry, pork and beef. However, more typically, at least one meat is found to be substitute for another. Some studies find pork and beef are substitutes while others find pork and chicken to be substitutes. Although, there does not appear to be a consensus in the literature on which meats are substitutes and which are complements. Also, consistent with previous findings, poultry was most sensitive to change in income (1.372) followed by pork (1.075) and then beef (0.538).

The second part of this chapter analyzed the changes in female and male population health status over time and due to changes in health claim policy in Canada. The results indicated that health claims did not have significant impacts on male health status but significantly affected female health status. While males were not directly affected by the health claims, male life expectancy has been improving, on average, by 0.611% per year over the sample period. The improvement of health over time suggests that males do respond to non-advertising health information, for example, information from physicians, family, friends, and media. In addition, for males, elasticity estimates from the Model 1 indicated that tobacco (-0.0508), fat (0.145), and pollution (-0.0322) negatively affects male life expectancy while alcohol (0.145) and fruit and vegetable consumption (0.0442) positively affects life expectancy. Elasticity estimates from Model 2 were very similar and the addition of the health claim variables did not add any significance to the model. The impacts of tobacco, alcohol, fruit and vegetable, and fat consumption and pollution were not surprising given findings in previous research.

As for females, the approval of the health claims in 2000 showed significant impacts on life expectancy. Specifically, a 1% increase in fruits and vegetable consumption was expected to increase life female expectancy by 0.0809% before the approval of the health claims in 2000 and increase life expectancy by 0.0199% after the approval. The smaller impact of fruits and vegetable consumption on health after the approval of the claim (0.0199%) compared to before (0.0809%) might be attributed to decreasing marginal benefits of fruits and vegetable consumption on health. In other words, the additional benefit of consuming fruit and vegetables declines the more fruit and vegetables are consumed.

Further, health claim policy showed significant impacts on fat consumption and health. A 1% increase in the consumption of fats was found to decrease female life expectancy by 0.0574% prior to the approval of the health claims in 2000 and increase female life expectancy by 0.0277% after the approval of the health claims. These results suggest that the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" might have encouraged the consumption of healthier fats, such as mono- and polyunsaturated, that are essential to good health thus contributing to the positive impact after 2000. The results also indicated that female life expectancy increased by 0.303% per year over the sample period. As with males, the improvement in female health over time suggests that females consider additional non-advertising health information, which contributes to good health.

In addition to the impacts of fats and fruit and vegetable consumption, elasticity estimates from Model 4 indicate that tobacco consumption (-0.0585) and pollution (-0.0526) negatively affect health while alcohol consumption (0.0635) had positive impacts. The results from Model 3 were very similar except they did not account for the effects of health claims. Again, the impacts of tobacco, alcohol, fruit and vegetable, and fat consumption and pollution on female health were not surprising given previous results found in the literature.

CHAPTER 6

6. Policy Implications

Cardiovascular disease and cancer have been the top two leading causes of mortality in Canada (Statistics Canada 2015). Research has found that many chronic illnesses are preventable and that the risk of chronic disease can be reduced significantly through the adoption of a healthy lifestyle, which includes a balanced and nutritious diet (CDC 2016; Ippolito and Mathios 1991; Thompson and Moughan 2008; WHO 2003). These illnesses, and many more, place substantial economic burden on society due to the direct public healthcare costs, such as the hospital expenditures and pharmaceutical expenditures, associated with them (Public Health Agency of Canada 2014). In addition, there are considerable indirect costs associated with a loss of productivity and costs that cannot be measured, such as reduction in the quality of life and wellbeing due to the suffering caused by illness. As a result, it is important that public health officials in Canada and abroad find policies that successfully influence dietary trends towards healthier foods.

The empirical results from this thesis suggest a few main conclusions with regards to the impacts of health claim policies and health information on consumer demand for functional foods in Canada and the U.S. First, the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease" health claim had significant negative impacts on the demand for margarine (high in trans fats) and the demand for pork (higher in saturated fats) in Canada after its approval in 2000. Second, in contrast, the disease risk reduction claim regarding "Fruits, Vegetables and Cancer" did not appear to have significant impacts on the demand for fruits and vegetables in Canada after its approval in 2000. Third, in the United States, the demand analysis revealed that when the health claim regarding "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease" was approved in 1993, there was a significant decrease in the consumption of butter, lard and beef (sources of saturated fats) and an increase in the demand for margarine and poultry (lower in saturated fats). Last, the results indicated that there were significant improvements over time in the consumption of fats and oils, meats, and fruits and vegetables in Canada and fats and meats in the U.S., suggesting that consumers take into consideration health information obtained from non-advertising sources.

There are several reasons the “Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)” and “Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)” health claims might have been successful at influencing consumption patterns compared to the “Fruits, Vegetables, and Cancer” health claim. First, studies on consumer attitudes towards functional foods and health claims suggest that consumers respond more favorably to claims that are personally relevant (e.g., Peng et al. 2006; van Kleef, van Trijp, and Luning 2005). It might be that the issue of dietary fat, cholesterol and CVD resonates with a larger portion of people than the relationship between fruits, vegetables and cancer. In fact, CVD accounts for 45% of all deaths globally whereas cancer accounts for 22% (WHO 2014). In addition, 47% of Americans have at least one of the following risk factors for heart disease: high cholesterol, high blood pressure, or are smokers (CDC 2015). Therefore, not only are more people directly affected by heart disease, but a large portion of the population have easily verifiable risk factors for the development of heart disease. Thus, when present on a label or in advertising, more consumers might respond to the “Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease” claim than the “Fruits, Vegetables and Cancer” claim due to familiarity or personal relevance.

A second reason the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease" and the "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" might have been more successful is that there was significant media attention on the issue of dietary fats and heart disease during the 1990s (Wasink and Cheney 2005). It is likely that this media attention facilitated greater consumer awareness and understanding about this health issue.

As for the "Fruits, Vegetables and Cancer" claim, there are a few reasons it might not have been as effective in Canada. First, it might be difficult for producers to place health claims on fresh food products, such as fresh fruits and vegetables found in the produce aisles, due to limited packaging. As a result, these claims might not reach consumers simply because they are underutilized. Second, even after health claims are approved it is up to the producers to decide whether they will or will not utilize them. Producers might choose not to use health claims due to the costs of labeling or perhaps they are unaware that their products are applicable the health claims, which can further limit the reach of these approved diet-health relationships on labels. Third, in the case health claims are present on labels, consumers might not understand the claims or labeling unaccompanied by other means of communication might not be sufficient to encourage consumers to change their dietary patterns (Wansink and Cheney 2005). Instead, it is recommended that a broader approach be taken where labeling of health claims supplements other means of educating consumers.

Last, it has been suggested that the reason some people engage in unhealthy behaviours is because of the rate at which they devalue future risks or benefits (Story et al. 2014). In the case of the "Fruits, Vegetables and Cancer (2000)" health claim, the benefits associated with a poor diet might not be easily verifiable or apparent for a long time and, as a result, consumers might perceive future rewards or risks to be very small. In comparison, the impacts of diet on cholesterol and high blood pressure might happen relatively more quickly and be easier to verify, for example, through blood tests.

6.1 Policy Suggestions

The consumption of functional foods is shown in Figure 1 in Section 4.1. The socially optimal level of consumption occurs at Q* where the marginal social benefit (MSB) equals the marginal social cost (MSC). In the absence of health claims, consumers are unaware of the benefits of consuming functional foods, resulting in their under consumption. At this point, marginal private benefit (MPB_1) is below marginal social benefit (MSB) and consumption occurs at Q_1. In the presence of health claims, consumers have an incentive to consume functional foods to improve health, MPB_1 shifts towards MPB_2 and the new consumption level is at Q_2, which is still below the optimal at Q*. Because of Canada's public healthcare system and private health insurance in the U.S., consumers do not bear the full costs of their dietary choices. Therefore, even in the presence of health claims, consumers do not have an incentive to reach the socially optimal level of consumption and other policies are needed to encourage further consumption of functional foods.

The first, and potentially the most cost-effective, policy recommendation is that public health authorities increase their means of communicating health information to consumers other than only through the regulation of health claims. As Wansink and Cheney (2005) suggested, health claims in tandem with other forms of communication can have greater impacts on consumption patterns. Other means of communicating health information include articles in popular media, radio advertisements, social media, and planned social events that get people directly involved in raising awareness (such as the CIBC Run for the Cure). In addition, public health authorities might collaborate with grocery stores to post educational campaigns in-stores. These forms of communication can facilitate healthy eating by raising awareness and understanding or, in the case of in-store education campaigns, can help increase the impact of health information on consumers as they are influenced directly at the point of purchase. Increasing methods of communication is particularly important for claims that are not as successful as it can help consumers become more familiar with the claims and better understand certain health issues.

Second, public health authorities could create a mandatory course in nutrition and well-being in the public education system. This course should begin when children enter school and are learning how to make decisions for themselves, then continue throughout the course of their secondary education. Many consumers might lack understanding on how to implement the advice in health claims or the full impacts on their health of their dietary choices. As a result, placing a greater emphasis on nutrition in schools could help consumers make healthier choices throughout their lives.

The third policy option involves the use of tax credits to consumers of functional foods. Tax credits can provide consumers with an incentive to increase their consumption of functional foods as they get additional benefit in the form of reduced taxes. A tax credit is a good option for increasing the consumption of foods where the use of health claims has not been as successful, for example, the "Fruits and Vegetables and Cancer" health claim. In this case, government could provide consumers with an annual monetary incentive to increase their fruits and vegetables consumption. As was previously discussed in Section 4.1, in the presence of health claims and other educational campaigns, MPB_1 shifts to MPB_2. However, if health claims are not completely successful, MPB_1 will only shift MPB' as shown in Figure 7. An appropriate amount of a tax credit to consumers of functional foods could be used to increase the benefit of consuming functional foods from MPB' to

MSB. The new optimal price and quantities after the incentive of the tax credit are at P_3 and Q*. The government would pay the difference between the new price, P_3, and the price consumers are willing to pay for Q* units on the original MPB' curve, P', per unit of consumption in the form of a tax credit. The total cost of the tax credit is indicated by the shaded area.

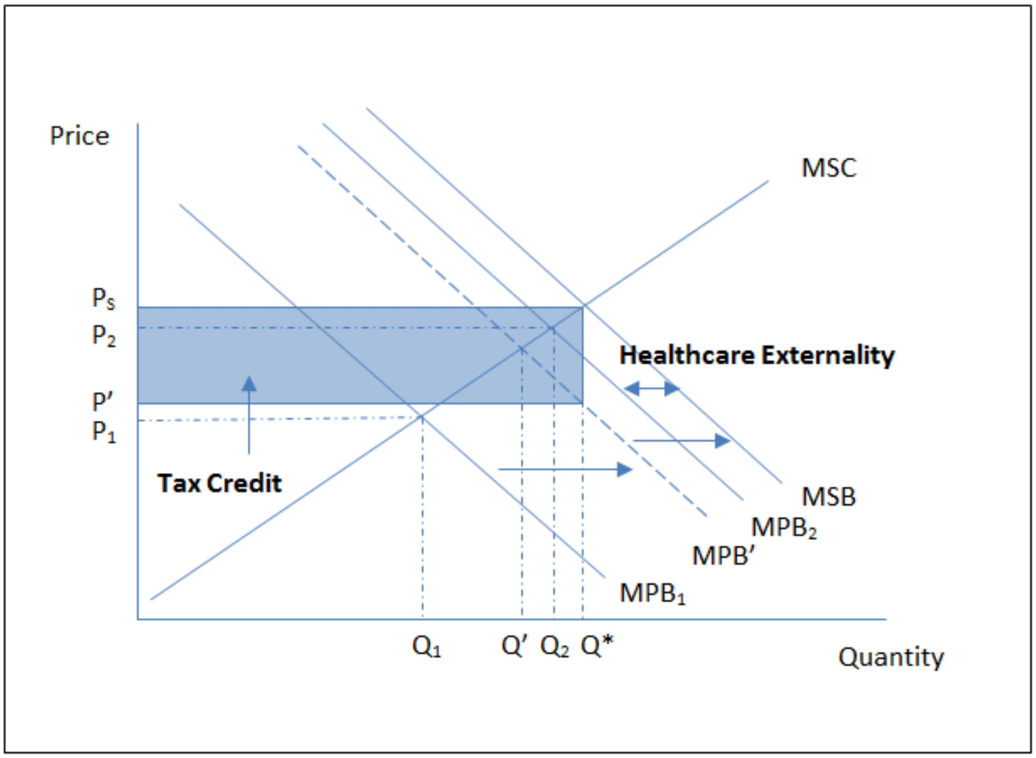

Figure 7. Impacts of a Tax Credit in the Functional Food Market

Source: Author

A fourth policy option includes the use of a subsidy on the costs of inputs to producers of functional foods. As shown in Figure 8, in the presence of health claims, the initial quantity of consumption prior to the use of a subsidy occurs at Q_2 where MPB_2 equals MSC_1. An appropriate amount of a subsidy on the cost of inputs would decrease the marginal cost of production and MSC_1 would shift right to MSC_2. The price paid by consumers would decrease from P_2 to P_4 resulting in an increase in the quantity demanded from Q_2 to Q^*. The new equilibrium price and quantity would occur at P_4 and Q^*. The cost of the subsidy paid by the government would be the difference between the cost of producing Q^* units on the original MSC_1 curve and the new MSC_2 curve. The total cost of the subsidy is represented by the shaded area.

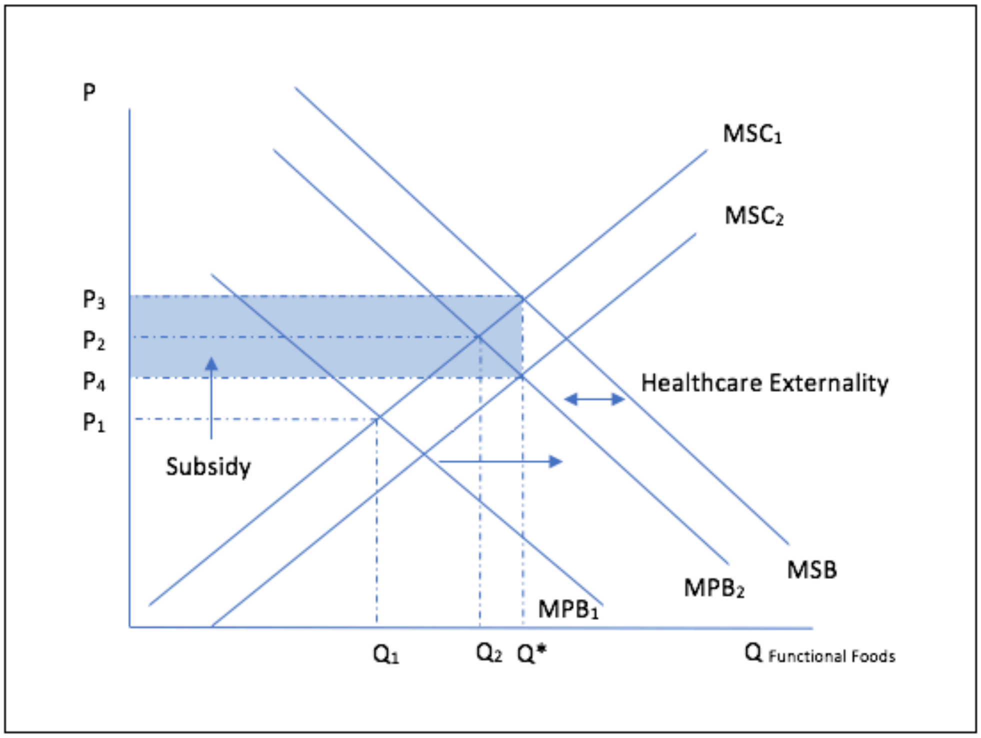

Figure 8. Health Claims and Subsidies on Functional Food Consumption

Source: Author

Both policy options, a tax credit or subsidy on the cost of inputs, could help increase consumption of healthy foods to the socially optimal level. However, the efficacy of these policies is dependent upon several factors. First, policy efficacy will depend upon how responsive consumers and producers are to changes in price. In terms of a tax credit policy that increases the marginal benefit of consuming functional foods, a relatively more elastic supply would result in a larger increase in quantity supplied than a less elastic supply as producers will be more responsive to changes in price caused by the increase in demand. As for a subsidy on the cost of inputs that increases the supply of functional foods, the policy will be more effective at increasing the quantity demanded when demand is relatively more elastic as consumers will be more responsive to changes in price caused by the increase in supply. The demand results for the Canadian own-price elasticities for fats, meats, and fruits and vegetables and U.S. own-price elasticities for fats and meats found in this thesis were all inelastic. In terms of a subsidy on the cost of inputs, inelastic own-prices from the demand analysis indicate that for every 1% decrease in own-price caused by the subsidy there would be a less than 1% increase in the quantity demanded of functional foods.

However, in addition to how responsive consumers are to changes in own-prices, the impacts of a tax credit or subsidy also are influenced by other factors (IISD n.d.). Those factors include whether the goods have close substitutes or if consumers substitute healthy foods with unhealthy foods reducing social welfare, if there are other government policies or programs that impact consumption patterns, such as subsidies in other industries, whether there is conflicting health or product information, or the period in which the policies are introduced.

In conclusion, the empirical results from this research have shown that certain health claims can be effective at improving dietary patterns. As a result, it is recommended that public health officials continue to regulate health claims as this provides consumers with credible, accurate, and reliable health information. To increase the success and effectiveness of health claim policy, it is recommended that public health officials increase other methods of communicating health information, such as media coverage, in-store educational campaigns, social media, and planned fundraising and awareness events, as this is likely to reach a larger proportion of consumers. Further, educational programs that begin teaching children in school at an early age about nutrition and continue to secondary school should be included in the public education curriculum.

Last, the use of health claims and educational efforts alone are not enough to increase demand to the socially optimal level. The government needs to use stronger economic and public policies that will provide consumers with an additional incentive to consume at the social optimal. The use of a tax credit to consumers or subsidy on the cost of production could significantly improve the consumption levels of functional foods leading to improved health and a reduction in public healthcare costs.

CHAPTER 7

7. Conclusions

An increasing incidence of chronic disease, rising public healthcare costs, and public awareness of the impacts of diet on health has led to an increased interest from consumers and producers in the functional food and natural health product industry. Functional foods are foods with increased health attributes compared to conventional foods. The use of health claims on labels and in advertising has created a solution to the issue of conveying the health benefits associated with the consumption of functional foods to consumers. In recent years, policymakers have developed health claim policies to encourage the consumption of functional foods and alleviate consumer misunderstandings about diet-health relationships. In addition, health authorities in Canada, the U.S., and the E.U. review and approve new health claims to ensure their validity and ensure that producers do not use false information to sell more products.

The primary objective of this thesis was to evaluate how health claim regulations in Canada and the U.S. have affected consumption patterns of healthy foods in each country. The approval of two Canadian health claims were analyzed for their impacts on relevant foods. First, the “Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)” health claim was analyzed for its impacts on the consumption of fats and oils and meats in Canada. Second, the “Fruits, Vegetables and Cancer (2000)” was analyzed for its impacts on the consumption of fruits and vegetables in Canada. In the U.S., the “Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)” was analyzed for its impacts on the consumption of fats and meats in the U.S.

A linear approximate almost ideal demand system (LA/AIDS) was estimated for each of the demand systems in Canada and the U.S. using iterative seemingly unrelated regression (SUR). The literature indicates that variations of both the AIDS and Rotterdam models, two of the most popular models used in demand analysis, can provide successful results depending on the datasets and issues being examined. Alston and Chalfant (1993) suggested that the demand model specification should not be randomly chosen *ex-ante*, but should instead be based on its suitability with the dataset being used. The absolute price Rotterdam and many variations of the AIDS models were initially specified, but the LA/AIDS was ultimately chosen to be the best fit for the data used in this thesis.

The secondary objective of this thesis was to evaluate how health claim policy and diet have affected the health status of North Americans and how health has changed over time. To determine the impacts of socioeconomic, lifestyle, and environmental factors on population health in North America, a logarithmic health production function was estimated using feasible generalized least squares (FGLS). Consistent with the literature, life expectancy at age 65 was used as a proxy for health status. The determinants of health included income, education, healthcare resources, fat consumption, fruit and vegetable consumption, tobacco, alcohol, and pollution.

Overall, the empirical results suggest that health claim policies have been effective at changing the demand for foods in Canada and the U.S. and that improvements in dietary patterns have coincided with better health outcomes in North America. First, the statistically significant results from the Canadian demand analysis show that the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" health claim successfully facilitated healthier consumption patterns. The demand for margarine (higher in trans fats during time of approval) and pork (higher in saturated fats) decreased by 3.83% and 1.4%, respectively. Further, the consumption patterns of fats and oils (1974 to 2016) and meats (1979 to 2016) improved significantly to reflect the changing dietary advice over the sample periods. On average, the demand for butter (0.25%), margarine (0.53%), pork (0.397%), and beef (0.19%) decreased each year over the sample period while the demand for salad oils (0.77%) and poultry (0.59%) increased.

In contrast, the "Fruits, Vegetables and Cancer (2000)" health claim did not significantly affect the demand for fruits and vegetables in Canada. The lack of significance of the "Fruits, Vegetables and Cancer (2000)" health claim might be due to limited ability for producers of certain products to use the claim due to packaging constraints or the costs associated with labelling. In addition, consumers might not relate or be as familiar with claims regarding fruits, vegetables, and cancer and, therefore, not as receptive to the claims. Lastly, public awareness about these diet-health relationships prior to when the claims were approved might have led consumers to begin changing consumption patterns before claims were approved by Health Canada.

While the "Fruits, Vegetables and Cancer (2000)" claim was not effective, the results indicated that Canadian consumers have been increasing their consumption of fruits and vegetables over time. Specifically, the demand for preserved fruit (0.4%) increased on average each year in Canada. The changes over time likely represent the effects of increasing related published research, media attention, and educational campaigns fruits and vegetables that occurred over the sample period.

As for the U.S, the empirical results from the demand analysis indicate that "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" health claim was effective at encouraging the consumption of a healthier diet that was lower in saturated fats in the U.S. The demand for foods relatively higher in saturated fats decreased after the approval of the health claim in 1993 while the demand for foods lower in saturated fats increased. Specifically, statistically significant results indicated that butter (7.10%), lard

(1.41%), and beef (2.42%) demand decreased while margarine (8.50%) and poultry (1.95%) increased after the approval of the U.S. health claim in 1993.

Like Canada, consumers in the U.S. also showed changes in consumption choices over time. On average, the demand for pork (0.24%/year) and margarine (1.38%/year) decreased over the period while the demand for butter (1.31%/year) and lard (0.073%/year) increased over the period. Although butter and lard are higher in saturated fats, the increase likely represents adjustments in consumption due to changes in awareness of the relatively more severe negative health consequences of trans fats compared to saturated fats.

The empirical results from the population health analysis indicated that health claims did not have significant impacts on male health status, but significantly affected female health status. While males were not directly affected by the health claims, male life expectancy improved, on average, by 0.611% per year over the sample period. The significance of the time trend suggests that males respond to health information obtained from sources other than health claims and this has led to an improvement in their health. In addition, diet was found to be a significant factor in male health status. Specifically, elasticity estimates indicated fat consumption negatively impacts male life expectancy (0.145) while fruit and vegetable consumption positively impacted male health (0.0442).

As for females, the empirical results indicated that the approval of the health claims in 2000 significantly affected female health status. Specifically, a 1% increase in fruits and vegetable consumption was expected to increase life female expectancy by 0.0809% before the approval of the health claims in 2000 and increase life expectancy by 0.0199% after the approval. The smaller impact of fruits and vegetable consumption on health after the approval of the claim (0.0199%) compared to before (0.0809%) might be due to decreasing marginal benefits of fruits and vegetable consumption on health.

Additionally, health claim policies showed significant impacts on fat consumption and health. A 1% increase in the consumption of fats was found to decrease female life expectancy by 0.0574% prior to the approval of the health claims in 2000 and increase female life expectancy by 0.0277% after the approval of the health claims. These results suggest that the "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" health claim might have encouraged the consumption of healthier fats, such as mono- and polyunsaturated fats, that are essential to good health, thus contributing to the positive impact of fat consumption on health after 2000. The results also indicated that female life expectancy increased by 0.303% per year over the sample period. As with males, the improvement in female health over time suggests that females consider health information from additional sources which contributes to good health.

Overall, the results from this study suggest that the Canadian "Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)" and the U.S. "Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)" health claims were successful at influencing consumption patterns in Canada and the U.S. In contrast, the "Fruits, Vegetables, and Cancer (2000)" health claim did not influence consumption patterns in Canada, possibly because consumers were not as aware or familiar with the diet-health relationship or the claims are not being used by producers due to constraints such as limited packaging.

Policy suggestions to improve the efficiency and effectiveness of current health claim regulations in Canada and the United States include increasing other means of communicating health information to consumers (e.g., popular media) and nutrition education programs, such as in public school systems or campaigns in grocery stores. In addition, where the health claims alone are not enough to change dietary patterns, a tax credit could be used as a monetary incentive to motivate consumers to increase their consumption of healthy foods, for example, fruits and vegetables. Last, a subsidy on the cost of inputs could help increase the consumption of health foods by reducing the marginal cost for producers and the final price paid by consumers. While population health status has seen significant improvements over time, there are still substantial economic burdens associated with chronic disease in Canada and abroad. Creating effective public policy related to the consumption of healthy foods is essential and area for further research.

This thesis contributes to the literature in several ways. First, this thesis contributes by assessing the efficacy of North American health claim regulations at changing consumer demand for foods. Second, it evaluates how health claim policies and diet impact population health status in North America. Last, this thesis provides policy recommendations that could improve the success of the current health claim policy at influencing consumption patterns towards healthier foods thus reducing the economic burden associated with chronic disease.

7.1 Limitations

The first limitation of this thesis is with respect to limited data on the prices and quantities of foods in Canada. Quarterly domestic disappearance data is not currently available through Statistics Canada, which limited the study to annual observations. In addition, annual average retail price data is available only from 1995 onwards, which does not provide enough observations to estimate a system of equations. As for using survey data, it is reported only intermittently which makes it difficult to examine changes over longer periods of time.

A second limitation of this study is that there appears to be some underlying issues when using data on aggregate prices and quantities currently available through Statistics

Canada for demand analysis. Initially, these demand systems were estimated using the absolute price Rotterdam model, then the first difference linear AIDS and, lastly, using the quadratic AIDS. However, none of these models produced satisfactory results that were consistent with demand theory. After further investigation into the issue, it was found that Goddard and Amuah (1989), Cox (1992) and Chang and Kinnucan (1991) also experienced similar issues with various models when using data on fats and oils obtained from Statistics Canada. In contrast, when using a comparable dataset from the U.S., these issues were not experienced.

References

Adhikari, Murali, Laxmi Paudel, Jack E. Houston, Krishna P. Paudel, and James Bukenya. 2006. The impact of cholesterol information on meat demand: application of an updated cholesterol index. *Journal of food distribution research* 37 (2): 60-69.

Adhikari, Murali, Laxmi Paudel, Krishna Paudel, Jack E. Houston, and James Bukenya. 2007. Impact of low carbohydrate information on vegetable demands in the United States. *Applied Economics Letters* 14 (13): 939-44.

Afonso, António, and Miguel St Aubyn. 2005. Non-parametric approaches to education and health efficiency in OECD countries. *Journal of Applied Economics* 8 (2): 227-46.

Agriculture and Agri-Food Canada (AAFC). 2012. Canada's Regulatory System for Foods with Health Benefits – An Overview of Industry. Canada: Agriculture and Agri-Food Canada.

Agriculture and Agri-Food Canada (AAFC). 2014. Opportunities and Challenges Facing the Canadian Functional Foods and Natural Health Products Sector. Canada: Agriculture and Agri-Food Canada.

Agriculture and Agri-Food Canada (AAFC). 2015. Functional Foods and Natural Health Products. http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/functional-foods-and-natural-health-products/?id=1170856376710#a (accessed April 3, 2016).

Agriculture and Agri-Food Canada (AAFC). 2016. Canadian Functional Foods and Natural Health Products: Rooted in quality and nurtured through innovation. http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/functional-foods-and-natural-health-products-sector/trends-and-market-opportunities-for-the-functional-foods-and-natural-health-products-sector/canadian-functional-foods-and-natural-health-products-rooted-in-quality-and-nurtured-through-innovation/?id=1400770710312 (accessed June 20, 2017)

Agriculture and Agri-Food Canada (AAFC). 2017a. Determine the Right Regulatory Framework for your Food of Natural Health Product. http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/functional-foods-and-natural-health-products-sector/determine-the-right-regulatory-framework-for-your-food-or-natural-health-product/?id=1489780945167 (accessed June 20, 2017)

Agriculture and Agri-Food Canada (AAFC). 2017b. Industry Overview of the Functional Foods and Natural Health Products Sector. http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/functional-foods-and-natural-health-products-sector/industry-overview-of-the-functional-foods-and-natural-health-products-sector/?id=1489778390460&wbdisable=true (accessed June 20, 2017)

Alston, Julian M., and James A. Chalfant. 1993. The silence of the lambdas: A test of the almost ideal and Rotterdam models. *American Journal of Agricultural Economics* 75(2): 304-13.

American Heart Association. 2016a. Dietary Fats. https://healthyforgood.heart.org/Eat-smart/Articles/Dietary-Fats (accessed September 15, 2017).

American Heart Association. 2016b. Polyunsaturated Fats. https://healthyforgood.heart.org/eat-smart/articles/polyunsaturated-fats (accessed September 15, 2017)

American Heart Association. 2017a. Monounsaturated Fats. https://healthyforgood.heart.org/Eat-smart/Articles/Monounsaturated-Fats (accessed July 6, 2017).

American Heart Association. 2017b. Saturated Fats. https://healthyforgood.heart.org/Eat-smart/Articles/Saturated-Fats (accessed September 15, 2017).

American Heart Association. 2017c. Trans Fats. https://healthyforgood.heart.org/eat-smart/articles/trans-fat (accessed September 15, 2017).

Anand, Sudhir, and Till Bärnighausen. 2004. Human resources and health outcomes: Cross-country econometric study. *The Lancet* 364 (9445): 1603-9.

Anders, Sven, and Anke Mőser. 2010. Consumer choice and health: The importance of health attributes for retail meat demand in Canada. *Canadian Journal of Agricultural Economics* 58 (2): 249-71.

Andreyeva, Tatiana, Michael W. Long, and Kelly D. Brownell. 2010. The impact of food prices on consumption: A systematic review of research on the price elasticity of demand for food. *American Journal of Public Health* 100 (2): 216-22.

Aschemann-Witzel, Jessica. 2011. The EU health claim regulation in international comparison: Review of the possible impact on food marketing and consumer protection. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 6* (33) 1-7.

Auster, Richard, Irving Leveson, and Deborah Sarachek. 1969. The production of health, an exploratory study. *The Journal of Human Resources* 4 (4): 411-36.

Barnett, William A., and Ousmane Seck. 2008. Rotterdam model versus almost ideal demand system: Will the best specification please stand up? *Journal of Applied Econometrics* 23 (6): 795-824.

Barreiro-Hurlé, J., S. Colombo, and E. Cantos-Villar. 2008. Is there a market for functional wines? consumer preferences and willingness to pay for resveratrol-enriched red wine. *Food Quality and Preference* 19 (4): 360-71.

Barten, Anton. P. 1964. Consumer demand functions under conditions of almost additive preferences. *Econometrica* 32 (1): 1-38.

Bayati, Mohsen, Reza Akbarian, and Zahra Kavosi. 2013. Determinants of life expectancy in eastern Mediterranean region: A health production function. *International Journal of Health Policy and Management* 1 (1): 57-61.

Behrman, Jere R., and Barbara L. Wolfe. 1984. The socioeconomic impact of schooling in a developing country. *The Review of Economics and Statistics* 66 (2): 296-303.

Berger, Mark C., and Jodi Messer. 2002. Public financing of health expenditures, insurance, and health outcomes. *Applied Economics* 34 (17): 2105-13.

Berndt, E. R., M. N. Darrough, and W. E. Diewert. 1977. Flexible functional forms and expenditure distributions: An application to Canadian consumer demand functions. *International Economic Review* 18 (3): 651-75.

Blaylock, James, David Smallwood, Kathleen Kassel, Jay Variyam, and Lorna Aldrich. 1999. Economics, food choices, and nutrition. *Food Policy* 24 (2): 269-86.

Boetel, Brenda L., and Donald J. Liu. 2003. Evaluating the effect of generic advertising and food health information within a meat demand system. *Agribusiness* 19 (3): 345-54.

Brester, Gary W., and Ted C. Schroeder. 1995. The impacts of brand and generic advertising on meat demand. *American Journal of Agricultural Economics* 77 (4): 969-79.

Brown, Deborah J., and Lee F. Schrader. 1990. Cholesterol information and shell egg consumption. *American Journal of Agricultural Economics* 72 (3): 548-55.

Brunello, Giorgio, Margherita Fort, Nicole Schneeweis, and Rudolf Winter-Ebmer. 2016. The causal effect of education on health: What is the role of health behaviors?. *Health economics* 25 (3): 314-336.

Bureau of Labor Statistics (BLS), U.S. Department of Labor. 2017a. *Series ID APU000716114 - Margarine, stick, per lb. (453.6 gm) in U.S. city average, average price, not seasonally adjusted.* Occupational Employment Statistics.

Bureau of Labor Statistics (BLS), U.S. Department of Labor. 2017b. *Series ID CUUR0000SEFF - Poultry in U.S. city average, all urban consumers, not seasonally adjusted.* Occupational Employment Statistics.

Bureau of Labor Statistics (BLS), U.S. Department of Labor. 2017c. *Series ID CUUR0000SEFD - Pork in U.S. city average, all urban consumers, not seasonally adjusted.* Occupational Employment Statistics.

Bureau of Labor Statistics (BLS), U.S. Department of Labor. 2017d. *Series ID CUUR0000SEFC - Beef and veal in U.S. city average, all urban consumers, not seasonally adjusted.* Occupational Employment Statistics.

Canadian Dairy Information Centre (CDIC). 2017. Canada's Dairy Industry at a Glance. http://www.dairyinfo.gc.ca/index_e.php?s1=cdi-ilc&s2=aag-ail (accessed November 28, 2017).

Canada Food Inspection Agency (CFIA). 2016a. Fortification. http://www.inspection.gc.ca/food/labelling/food-labelling-for-industry/fortification/eng/1468504433692/1468504697186 (accessed July 4, 2017)

Canada Food Inspection Agency (CFIA). 2016b. Health Claims. http://www.inspection.gc.ca/food/labelling/food-labelling-for-industry/health-claims/eng/1392834838383/1392834887794?chap=0 (accessed April 3, 2016).

Canada Food Inspection Agency (CFIA). 2016c. Specific Nutrient Content Claim Requirements – Energy and Calorie Claims. http://www.inspection.gc.ca/food/labelling/food-labelling-for-industry/nutrient-content/specific-claim-requirements/eng/1389907770176/1389907817577?chap=0 (accessed July 4, 2017).

Canadian Food Inspection Agency (CFIA). 2016d. Foods Always Exempt from Carrying a Nutrition Facts Table. http://www.inspection.gc.ca/food/labelling/food-labelling-for-industry/nutrition-labelling/exemptions/eng/1389198015395/1389198098450?chap=1 (accessed September 4, 2017).

Capps, Oral, and John D. Schmitz. 1991. A recognition of health and nutrition factors in food demand analysis. *Western Journal of Agricultural Economics* 16 (1): 21-35.

Cardon, James H., and Rulon D. Pope. 2003. Agricultural market structure, generic advertising, and welfare. *Journal of Agricultural and Resource Economics* 28 (2): 185-200.

Cardwell, Ryan, Chad Lawley, and Di Xiang. 2015. Milked and feathered: The regressive welfare effects of canada's supply management regime. *Canadian Public Policy / Analyse De Politiques* 41 (1): 1-14.

Carter, Colin A., and Pierre Mérel. 2016. Hidden costs of supply management in a small market. *Canadian Journal of Economics/Revue Canadienne d'Économique* 49 (2): 555-88.

Centers for Disease Control and Prevention (CDC). 2015. Heart Disease Risk Factors. https://www.cdc.gov/heartdisease/risk_factors.htm (accessed September 22, 2017).

Centers for Disease Control and Prevention (CDC). 2016. Heart Disease Fact Sheet. https://www.cdc.gov/dhdsp/data_statistics/fact_sheets/fs_heart_disease.htm (accessed July 7, 2017).

Centers for Disease Control and Prevention (CDC). 2017a. Chronic Disease Overview. http://www.cdc.gov/chronicdisease/overview/index.htm (accessed June 20, 2017)

Centers for Disease Control and Prevention (CDC). 2017b. Health Effects of Cigarette Smoking. https://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/effects_cig_smoking/index.htm (accessed January 7, 2017).

Chalfant, James A. 1987. A globally flexible, almost ideal demand system. *Journal of Business & Economic Statistics* 5(2): 233-242.

Chandon, Pierre. 2013. How package design and packaged-based marketing claims lead to overeating. *Applied Economics Perspective and Policy* 35 (1): 7-31.

Chandon, Pierre, and Brian Wansink. 2012. Does food marketing need to make us fat? A review and solutions. *Nutrition reviews* 70 (10): 571-593.

Chang, Hui-Shung, and Henry W. Kinnucan. 1991. Advertising, information, and product quality: the case of butter. *American Journal of Agricultural Economics* 73 (4): 1195-1203.

Chern, Wen S., Edna T. Loehman, and Steven T. Yen. 1995. Information, health risk beliefs, and the demand for fats and oils. *The Review of Economics and Statistics* 77 (3): 555-64.

Chicago Booth. n.d. Nielsen Dataset. https://research.chicagobooth.edu/nielsen/datasets#simple2 (accessed September 5, 2017)

Christensen, Laurits R., Dale W. Jorgenson, and Lawrence J. Lau. 1975. Transcendental logarithmic utility functions. *The American Economic Review* 65 (3): 367-83.

Chrysochou, Polymeros, and Klaus G. Grunert. 2014. Health-related ad information and health motivation effects on product evaluations. *Journal of Business Research* 67 (6): 1209-17.

Clements, Kenneth W., and Grace Gao. 2015. The Rotterdam demand model half a century on. *Economic Modelling* 49: 91-103.

Cox, Thomas L. 1992. A Rotterdam model incorporating advertising effects: The case of Canadian fats and oils. *Commodity Advertising and Promotion,* edited by Henry W. Kinnucan, Stanley R. Thompson, and Hui-Shung Chung. Ames, Iowa: Iowa State University Press.

Cranfield, John. 2012. Did BSE affect demand for beef in Canada? An application of the quadratic almost ideal demand system. *Institute for the Advanced Study of Food and Agricultural Policy Working Paper Series–12-01. Guelph: Department of Food, Agricultural and Resource Economics, University of Guelph.*

Crémieux, Pierre-Yves, Pierre Ouellette, and Caroline Pilon. 1999. Health care spending as determinants of health outcomes. *Health Economics* 8 (7): 627-39.

Coppens, Patrick, Miguel Fernandes da Silva, and Simon Pettman. 2006. European regulations on nutraceuticals, dietary supplements and functional foods: A framework based on safety. *Toxicology* 221 (1): 59-74.

Dahlen, Micael, and Sara Rosengren. 2016. If advertising won't die, what will it be? toward a working definition of advertising. *Journal of Advertising* 45 (3): 334-45.

Dameus, Alix, Francisca G. -C Richter, B. Wade Brorsen, and Kullapapruk Piewthongngam Sukhdial. 2002. AIDS versus the Rotterdam demand system: A cox test with parametric bootstrap. *Journal of Agricultural and Resource Economics* 27 (2): 335-47.

Deaton, Angus, and John Muellbauer. 1980. An almost ideal demand system. *The American Economic Review* 70 (3): 312-26.

Dedah, Cheikhna, Walter R. Keithly, and Richard F. Kazmierczak. 2011. An analysis of US oyster demand and the influence of labeling requirements. *Marine Resource Economics* 26 (1): 17-33.

Dieticians of Canada. 2016. Food Sources of Iron. https://www.dietitians.ca/Your-Health/Nutrition-A-Z/Minerals/Food-Sources-of-Iron.aspx (accessed September 1, 2017).

Dieticians of Canada. 2017a. Food Sources of Vitamin B12. https://www.dietitians.ca/Your-Health/Nutrition-A-Z/Vitamins/Food-Sources-of-Vitamin-B12.aspx

Dieticians of Canada. 2017b. Food Sources of Zinc. https://www.dietitians.ca/Your-Health/Nutrition-A-Z/Minerals/Food-Sources-of-Zinc.aspx (accessed September 1, 2017).

Dietz, William H., Clifford E. Douglas, and Ross C. Brownson. 2016. Chronic disease prevention: Tobacco avoidance, physical activity, and nutrition for a healthy start. *Jama* 316 (16): 1645-6.

Ding, Yulian L., Michele M. Veeman, and Wiktor L. Adamowicz. 2015. Functional food choices: Impacts of trust and health control beliefs on Canadian consumers' choices of canola oil. *Food Policy* 52: 92-98.

Dubock, Adrian. 2014. The politics of golden rice. *GM Crops & Food* 5 (3): 210-22.

Eales, James S., and Laurian J. Unnevehr. 1988. Demand for beef and chicken products: separability and structural change. *American Journal of Agricultural Economics* 70 (3): 521-32.

Economic Research Services (ERS), U.S. Department of Agriculture. 2017a. Food Availability (Per Capita) Data System. https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/ (accessed June 17, 2017).

Economic Research Services (ERS), U.S. Department of Agriculture. 2017b. *Table 40 - Margarine (actual weight): Supply and disappearance, U.S., 1980-2010.* Oil Crops Yearbooks.

Economic Research Services (ERS), U.S. Department of Agriculture. 2017c. *Table 42--Lard: Supply, disappearance, and price, U.S., 1980-2016*. Oil Crops Yearbooks.

Economic Research Services (ERS), U.S. Department of Agriculture. 2017d. *Table 43--Butter (actual weight): Supply, disappearance, and price, U.S., 1980-2016*. Oil Crops Yearbooks.

Edgerton, David L. 1997. Weak separability and the estimation of elasticities in multistage demand systems. *American Journal of Agricultural Economics* 79 (1): 62-79.

European Commission (EC). 2015. Evaluation and Fitness Check (FC) Roadmap. http://ec.europa.eu/smart-regulation/roadmaps/docs/2015_sante_595_evaluation_health_claims_en.pdf (accessed August 2, 2016).

European Commission (EC). 2017a. Health claims. http://ec.europa.eu/food/safety/labelling_nutrition/claims/health_claims/index_en.htm (accessed July 1, 2017).

European Commission (EC). 2017b. Food supplements. https://ec.europa.eu/food/safety/labelling_nutrition/supplements_en (accessed July 17, 2017).

European Commission (EC). 2017c. Nutrition and Health Claims. http://ec.europa.eu/food/safety/labelling_nutrition/claims/index_en.htm (accessed July 1, 2017)

European Commission (EC). 2017d. Nutrition claims. http://ec.europa.eu/food/safety/labelling_nutrition/claims/health_claims/index_en.htm (accessed August 2, 2016)

European Commission (EC). Directive 2002/46/EC of the European Parliament and of the Council of 10 June 2002 on the approximation of the laws of the Member States relating to food supplements (Text with EEA relevance). *OJ L* 183: 51–57.

European Commission (EC). n.d. EU Register on nutrition and health claims. http://ec.europa.eu/nuhclaims/?event=search (accessed August 3, 2016).

European Food Information Council (EUFIC). 2006. Functional Foods. http://www.eufic.org/en/food-production/article/functional-foods (accessed March 29, 2016).

European Food Safety Authority (EFSA). n.d.(a) Claims on disease risk reduction and child development or health under Article 14. https://www.efsa.europa.eu/en/topics/topic/article14 (accessed August 1, 2016).

European Food Safety Authority (EFSA). n.d.(b). Food Supplements. http://www.efsa.europa.eu/en/topics/topic/food-supplements (accessed August 1, 2016)

European Food Safety Authority (EFSA). n.d.(c) "General function" health claims under Article 13. https://www.efsa.europa.eu/en/topics/topic/article13 (accessed August 1, 2016).

European Food Safety Authority (EFSA). n.d.(d). "New function" health claims under Article 13.5. https://www.efsa.europa.eu/en/topics/topic/article13-5 (accessed August 1, 2016).

Faroque, Akhter. 2008. An investigation into the demand for alcoholic beverages in Canada: A choice between the almost ideal and the rotterdam models. *Applied Economics* 40 (16): 2045-54.

Farquhar, William B., David G. Edwards, Claudine T. Jurkovitz, and William S. Weintraub. 2015. Dietary sodium and health. *Journal of the American College of Cardiology* 65 (10): 1042-50.

Fayissa, Bichaka, and Paulos Gutema. 2005. Estimating a health production function for Sub-Saharan Africa (SSA). *Applied Economics* 37 (2): 155-64.

Filmer, Deon, and Lant Pritchett. 1999. The impact of public spending on health: Does money matter? *Social Science & Medicine* 49 (10): 1309-23.

Food and Drugs Regulation, C.R.C., c. 870, B.01.514 to B.01.599.

Food and Nutrition Services (FNS), U.S. Department of Agriculture. 2017. 5 A Day. https://www.fns.usda.gov/tn/5-day (accessed September 15, 2017).

Foreign Agricultural Service. 2016. Nutrition and Health Claims. http://www.usda-eu.org/trade-with-the-eu/eu-import-rules/nutrition-health-claims/ (accessed August 2, 2016).

International Initiative for Sustainable Development (IISD). n.d. Chapter 2: The effects of subsidies. https://www.iisd.org/GSI/effects-subsidies (accessed November 19, 2017).

Goddard, Ellen W., and Alex K. Amuah. 1989. The demand for Canadian fats and oils: A case study of advertising effectiveness. *American Journal of Agricultural Economics* 71 (3): 741-49.

Goddard, Ellen W., and Alex K. Amuah. 1991. Erratum: The demand for Canadian fats and oils: A case study of advertising effectiveness. *American Journal of Agricultural Economics* 73 (2): 502.

Goodman, Samantha, David Hammond, Rhona Hanning, and Judy Sheeshka. 2013. The impact of adding front-of-package sodium content labels to grocery products: An experimental study. *Public Health Nutrition* 16 (3): 383-91.

Government of Canada. 2012a. Functional Foods and Natural Health Products: Canada's Competitive Advantage. Government of Canada Publication. Catalogue FR5-38/19-2012E. http://publications.gc.ca/collections/collection_2012/aecic-faitc/FR5-38-19-2012-eng.pdf (accessed October 8, 2016).

Government of Canada. 2012b. Nutrition Claims. https://www.canada.ca/en/health-canada/services/understanding-food-labels/nutrition-claims.html (accessed April 17, 2016)

Government of Canada. 2013. Tips for Fruits and Vegetables. https://www.canada.ca/en/health-canada/services/food-nutrition/canada-food-guide/choosing-foods/vegetables-fruit/tips-fruits-vegetables.html (accessed July 18, 2017).

Government of Canada. 2015. Nutrition facts tables. https://www.canada.ca/en/health-canada/services/understanding-food-labels/nutrition-facts-tables.html (accessed September 6, 2017).

Gray, Richard, Stavroula Malla, and Ken Perlich. 2006. Economic impacts of proposed limits on trans fats in Canada. *Current Agriculture, Food and Resource Issues* (7): 149-61.

Green, Richard, and Julian M. Alston. 1990. Elasticities in AIDS models. *American Journal of Agricultural Economics* 72 (2): 442-45.

Harris, J. Michael and Rimma Shiptsova. 2007. Consumer Demand for Convenience Foods: Demographics and Expenditures. *Journal of Food Distribution Research* 38(3): 1-36.

Hasler, Clare M. 2008. Health claims in the United States: An aid to the public or a source of confusion? *The Journal of Nutrition* 138 (6): 1216S-1220S.

Health Canada. 1998. Nutraceuticals/Functional Foods and Health Claims on Foods Policy Paper. Government of Canada.

Health Canada. 2000. ARCHIVED – Health Canada Scientific Summary of the U.S. Health Claim Regarding Fruits, Vegetables and Cancer. https://www.canada.ca/en/health-canada/services/food-nutrition/food-labelling/health-claims/assessments/scientific-summary-health-claim-regarding-fruits-vegetables-cancer.html (accessed September 15, 2017).

Health Canada. 2006. Labeling Guidance Document, Natural Health Products Directorate. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/dhp-mps/alt_formats/hpfb-dgpsa/pdf/prodnatur/labelling-etiquetage-eng.pdf (accessed October 20, 2016)

Health Canada. 2009. Guidance Document for Preparing a Submission for Food Health Claims. Bureau of Nutritional Sciences, Food Directorate, Health Products and Food Branch. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/fn-an/alt_formats/hpfb-dgpsa/pdf/legislation/health-claims_guidance-orientation_allegations-sante-eng.pdf (accessed April 17, 2017).

Health Canada. 2010. Nutrition Claims. http://www.hc-sc.gc.ca/fn-an/label-etiquet/nutrition/cons/claims-reclam/index-eng.php (accessed April 17, 2016).

Health Canada. 2013. Guidance Document: Schedule A and Section 3 to the Food and Drugs Act [Health Canada, 2010]. https://www.canada.ca/en/health-canada/services/drugs-health-products/drug-products/applications-submissions/guidance-documents/guidance-document-schedule-section-3-food-drugs-act.html (accessed August 24, 2017).

Health Canada. 2014. Summary of Canada's Assessment of a Health Claim about Ground Whole Flaxseed and Blood Cholesterol Lowering. https://www.canada.ca/en/health-canada/services/food-nutrition/food-labelling/health-claims/assessments/ground-whole-flaxseed-blood-cholesterol-lowering-nutrition-health-claims-food-labelling.html (accessed July 4, 2017).

Health Canada. 2016a. About Natural Health Products. http://www.hc-sc.gc.ca/dhp-mps/prodnatur/about-apropos/cons-eng.php (accessed July 16, 2016).

Health Canada. 2016b. About Natural Health Product Regulations in Canada. http://www.hc-sc.gc.ca/dhp-mps/prodnatur/about-apropos/index-eng.php (accessed October 4, 2016).

Health Canada. 2016c. Health Claims. http://www.hc-sc.gc.ca/fn-an/label-etiquet/claims-reclam/index-eng.php (accessed July 23, 2016).

Health Canada. 2016d. Health Claim Assessments. http://www.hc-sc.gc.ca/fn-an/label-etiquet/claims-reclam/assess-evalu/index-eng.php (accessed August 1, 2016).

Health Canada. 2016e. Summary of Health Canada's assessment of a health claim about a polysaccharide complex (glucomannan, xanthan gum, sodium alginate) and a reduction of the post-prandial blood glucose response. Bureau of Nutritional Sciences, Food Directorate, Health Products and Food Branch Paper, Government of Canada.

Heick, W.H. 2006. *A propensity to protect: butter, margarine and the rise of urban culture in Canada.* Wilfrid Laurier University Press: Waterloo, Ontario.

Henson, Spencer, Deepananda Herath, and John Cranfield. 2006. A note on the economic rationale for regulating health claims on functional foods and nutraceuticals: The case of Canada. *Health Law Review* 15 (1): 23-32.

Herath, Deepananda, John Cranfield, and Spencer Henson. 2008. Who consumes functional foods and nutraceuticals in Canada? Results of cluster analysis of the 2006 survey of Canadians' Demand for Food Products Supporting Health and Wellness. *Appetite* 51 (2): 256-65.

Herath, Deepananda, John Cranfield, and Spencer Henson. 2010. Understanding the financing of innovation and commercialization: The case of the Canadian functional food and nutraceutical sector. *Applied Economics* 42 (21): 2667-82.

Hoad, Darren. 2011. Scientific method and the regulation of health and nutritional claims by the European Food Safety Authority. *Bulletin of Science, Technology & Society* 31(2): 123-33.

Hoppert, Karin, Susann Zahn, Luise Jänecke, Robert Mai, Stefan Hoffmann, and Harald Rohm. 2013. Consumer acceptance of regular and reduced-sugar yogurt enriched with different types of dietary fiber. *International Dairy Journal* 28 (1): 1-7.

Hobbs, Jill E., Stavroula Malla, and Eric K. Sogah. 2014. Regulatory frameworks for functional food and supplements. *Canadian Journal of Agricultural Economics/Revue Canadienne d'Agroeconomie* 62 (4): 569-94.

Hobbs, Jill E., Stavroula Malla, Eric K. Sogah, and May T. Yeung. 2014. *Regulating Health Foods: Policy Challenges and Consumer Conundrums.* Cheltenham, UK: Edward Elgar Publishing Limited.

Huang, Lei, and Ji Lu. 2016. The impact of package color and the nutrition content labels on the perception of food healthiness and purchase intention. *Journal of Food Products Marketing* 22 (2): 191-218.

Humphreys, Brad R., Logan McLeod, and Jane E. Ruseski. 2014. Physical activity and health outcomes: Evidence from Canada. *Health Economics* 23 (1): 33-54.

Hwang, Johye, Kiwon Lee, and Ting-Ning Lin. 2016. Ingredient labeling and health claims influencing consumer perceptions, purchase intentions, and willingness to pay. *Journal of Foodservice Business Research* 19 (4): 352-67.

International Food Information Council (IFIC). 2013. Functional Foods Consumer Survey Executive Research Report.

Ippolito, Pauline M., and Alan D. Mathios. 1991. Health claims in food marketing: Evidence on knowledge and behavior in the cereal market. *Journal of Public Policy & Marketing* 10 (1): 15-32.

Joumard, Isabelle, Christophe André, Chantal Nicq, and Olivier Chatal. 2010. Health status determinants: lifestyle, environment, health care resources and efficiency. OECD Economics Department Working Paper No. 627.

Key, Tim. J. 2011. Fruit and vegetables and cancer risk. *British Journal of Cancer* 104 (1): 6-11.

Khamphoune, Beau. 2013. Results from the 2011 Functional Foods and Natural Health Products Survey. Statistics Canada Working Paper, Catalogue 18-001-X, September. http://www.statcan.gc.ca/pub/18-001-x/18-001-x2013001-eng.pdf (accessed April 10, 2016).

Stanhope, Kimber L. 2016. Sugar consumption, metabolic disease and obesity: The state of the controversy. *Critical Reviews in Clinical Laboratory Sciences* 53 (1): 52-67.

Kinnucan, Henry W., Hui Xiao, Chung-Jen Hsia, and John D. Jackson. 1997. Effects of health information and generic advertising on U.S. meat demand. *American Journal of Agricultural Economics* 79 (1): 13-23.

Krutulyte, Rasa, Klaus G. Grunert, Joachim Scholderer, Liisa Lähteenmäki, Kit S. Hagemann, Peter Elgaard, Brian Nielsen, and Jens Peter Graverholt. 2011. Perceived fit of different combinations of carriers and functional ingredients and its effect on purchase intention. *Food Quality and Preference* 22 (1): 11-6.

Lapointe, S. 2008. IP Protection for Nutraceuticals and Functional Foods. *Health Law in Canada* 28(3-4).

Leatherhead. 2014. Future Directions for the Global Functional Foods Market. Market Report.

Lesser, William. 1998. Intellectual property rights and concentration in agricultural biotechnology. *AgBioForum 1*(2): 56-61.

Livestrong. 2014. Foods With Iron and Zinc. http://www.livestrong.com/article/30835-foods-iron-zinc/ (accessed September 1, 2017).

Llavinés, Francesc P. 2013. The communication of health claims for foods: A review of consumer perceptions. *Catalan Journal of Communication & Cultural Studies* 5 (2): 255-69.

Lu, Ji. 2015. The effect of perceived carrier-ingredient fit on purchase intention of functional food moderated by nutrition knowledge and health claim. *British Food Journal* 117 (7): 1872-85.

Mackie, Alexander, Ivan Haščič, and Miguel Cárdenas Rodríguez. 2016. Population exposure to fine particles: Methodology and results for OECD and G20 countries. OECD Publishing.

Malla, Stavroula, Jill E. Hobbs and Eric K. Sogah. 2013. Functional foods and natural health products regulations in Canada and around the world: nutrition labels and health claims. *Saskatoon, Saskatchewan, Canada: Report prepared for the Canadian Agricultural Innovation and Regulation Network*.

Mariotti, François, Esther Kalonji, Jean François Huneau, and Irène Margaritis. 2010. Potential pitfalls of health claims from a public health nutrition perspective. *Nutrition Reviews* 68 (10): 624-38.

MarketLine. 2012. *Benecol case study: A leader in cholesterol-reducing foods*. Retrieved from MarketLine Advantage (database).

MarketLine. 2014. *Functional Foods: Growth of a niche market*. Retrieved from MarketLine Advantage database.

Markosyan, Armenak, Jill J. McCluskey, and Thomas I. Wahl. 2009. Consumer response to information about a functional food product: Apples enriched with antioxidants. *Canadian Journal of Agricultural Economics* 57 (3): 325-41.

Mathios, Alan D. 2000. The impact of mandatory disclosure laws on product choices: An analysis of the salad dressing market. *The Journal of Law & Economics* 43 (2): 651-78.

Maynard, Leigh J., and Sharon T. Franklin. 2003. Functional foods as a value-added strategy: The commercial potential of "cancer-fighting" dairy products. *Review of Agricultural Economics* 25 (2): 316-31.

Miklavec, Krista, Igor Pravst, Klaus G. Grunert, Marija Klopčič, and Jure Pohar. 2015. The influence of health claims and nutritional composition on consumers' yoghurt preferences. *Food Quality and Preference* 43: 26-33.

Miller, Jr RD, and H. E. Frech. 2000. Is there a link between pharmaceutical consumption and improved health in OECD countries?. *Pharmacoeconomics* 18: 33-45.

Milner, J.A. 1999. Functional foods and health promotion. *Journal of Nutrition* 129 (7): 1395S-7S.

Public Health Agency of Canada. 2014. Economic Burden of Illness in Canada, 2005-2008. Catalogue HP50-1/2013E-PDF, Publication No. 130148. Minister of Health.

Moors, Ellen H.M. 2012. Functional foods: regulation and innovations in the EU. *Innovation: The European Journal of Social Science Research* 25(4): 424-40.

Mozaffarian, Dariush, Emelia J. Benjamin, Alan S. Go, Donna K. Arnett, Michael J. Blaha, Mary Cushman, Sandeep R. Das, Sarah de Ferranti, Jean-Pierre Despr.s, Heather J. Fullerton, Virginia J. Howard, Mark D. Huffman, Carmen R. Isasi, Monik C. Jim.nez, Suzanne E. Judd, Brett M. Kissela, Judith H. Lichtman, Lynda D. Lisabeth, Simin Liu, Rachel H.

Mackey, David J. Magid, Darren K. McGuire, Emile R. Mohler III, Claudia S. Moy, Paul Muntner, Michael E. Mussolino, Khurram Nasir, Robert W. Neumar, Graham Nichol, Latha Palaniappan, Dilip K. Pandey, Mathew J. Reeves, Carlos J. Rodriguez, Wayne Rosamond, Paul D. Sorlie, Joel Stein, Amytis Towfighi, Tanya N. Turan, Salim S. Virani, Daniel Woo, Robert W. Yeh, Melanie B. Turner, on behalf of the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. 2016. Executive summary: heart disease and stroke statistics—2016 update: a report from the American Heart Association. *Circulation* 133: 447-454.

Natural Health Products Directorate (NHPD), Health Canada. 2006. Labelling and Guidance Document. Catelogue No. H164-24/2006E-PDF. Ottawa: Minister of Health.

Naylor, Rebecca Walker, Courtney M. Droms, and Kelly L. Haws. 2009. Eating with a purpose: Consumer response to functional food health claims in conflicting versus complementary information environments. *Journal of Public Policy & Marketing* 28 (2): 221-33.

Nichele, Veronique. 2003. Health Information and Food Demand in France. Chern, Wen S., Kyrre Rickertsen, and Inc NetLibrary. *Health, nutrition and food demand*. Wallingford, UK: CABI Pub.

Ohama, Hirobumi, Hideko Ikeda, and Hiroyoshi Moriyama. 2006. Health foods and foods with health claims in japan. *Toxicology* 221 (1): 95-111.

Or, Zeynep. 2001. Exploring the Effects of Health Care on Mortality Across OECD Countries. OECD Labour Market and Social Policy Occasional Papers, No. 46. OECD Publishing: Paris.

OECD. 2016. *OECD Health Statistics (database).*

OECD/EU. 2016. *Health at a Glance: Europe 2016: State of Health in the EU Cycle*. OECD Publishing: Paris.

Peng, Yanning, Gale E. West, and Cindy Wang. 2006. Consumer Attitudes and Acceptance of CLA-Enriched Dairy Products. *Canadian Journal of Agricultural Economics/Revue Canadienne D'agroeconomie* 54(4): 663-84.

Piggott, Nicholas E. and Thomas L. Marsh. 2004. Does food safety information impact U.S. meat demand? *American Journal of Agricultural Economics* 86 (1): 154-74.

Polkinghorne, R. J., and J. M. Thompson. 2010. Meat standards and grading. *Meat Science*86 (1): 227-35.

Pollak, Robert A. and Terence J. Wales. 1992. *Demand system specification and estimation*. New York: Oxford University Press.

Pomboza, Ruth, and Msafiri Daudi Mbaga. 2007. *The estimation of food demand elasticities in Canada*. No. 52705. Agriculture and Agri-Food Canada.

Ratnayake, W. M. N., C. Gagnon, L. Dumais, W. Lillycrop, L. Wong, M. Meleta, and P. Calway. 2007. trans fatty acid content of Canadian margarines prior to mandatory trans fat labelling. *Journal of the American Oil Chemists' Society* 84 (9): 817-25.

Resnik, David. 2010. Trans fat bans and human freedom. *The American Journal of Bioethics*10 (3): 27-32.

Richardson, David P., and Manfred Eggersdorfer. 2015. Opportunities for product innovation using authorised European Union health claims. *International Journal of Food Science & Technology* 50 (1): 3-12.

Rickertsen, Kyrre, Dadi Kristofersson, and Solveig Lothe. 2003. Effects of health information on Nordic meat and fish demand. *Empirical Economics* 28 (2): 249-73.

Rickman, Joy C., Diane M. Barrett, and Christine M. Bruhn. 2007. Nutritional comparison of fresh, frozen and canned fruits and vegetables. part 1. vitamins C and B and phenolic compounds. *Journal of the Science of Food and Agriculture* 87 (6): 930-44.

Rodriguez, Nestor, and James S. Eales. 2015. Structural Change via Threshold Effects: Estimating US Meat Demand Using Smooth Transition Functions and the Effects of More Women in the Labor Force. In *2015 AAEA & WAEA Joint Annual Meeting, July 26-28, San Francisco, California*, no. 206522. Agricultural and Applied Economics Association & Western Agricultural Economics Association.

Roe, Brian, Alan S. Levy, and Brenda M. Derby. 1999. The impact of health claims on consumer search and product evaluation outcomes: Results from FDA experimental data. *Journal of Public Policy & Marketing* 18 (1): 89-105.

Romley, John, and Neeraj Sood. 2013. Identifying the health production function: The case of hospitals. NBER Working Paper no. 19490. National Bureau of Economic Research. Cambridge, MA.

Salman, Khalik, Leif Arnesson, Anna Sörensson, Ghazi Shukur. 2010. Estimating international tourism demand for selected regions in Sweden and Norway with iterative seemingly unrelated regressions (ISUR). *Scandinavian Journal of Hospitality and Tourism* 10 (4): 395-410.

Schleifer, David. 2012. The perfect solution: How trans fats became the healthy replacement for saturated fats. *Technology and Culture* 53 (1): 94-119.

Shaw, James W., William C. Horrace, and Ronald J. Vogel. 2005. The determinants of life expectancy: an analysis of the OECD health data. *Southern Economic Journal* 71 (4): 768-783.

Shimshack, Jay P., Michael B. Ward, and Timothy K. M. Beatty. 2007. Mercury advisories: Information, education, and fish consumption. *Journal of Environmental Economics and Management* 53 (2): 158-79.

Siró, István, Emese Kápolna, Beáta Kápolna, and Andrea Lugasi. 2008. Functional food. Product development, marketing and consumer acceptance—A review. *Appetite* 51 (3): 456-67.

Statistics Canada. 2015. The 10 Leading Causes of Death. http://www.statcan.gc.ca/pub/82-625-x/2014001/article/11896-eng.htm (accessed June 30, 2017)

Statistics Canada. 2016. Food supply and disposition. http://www23.statcan.gc.ca/imdb-bmdi/document/3475_D1_T9_V3-eng.htm (accessed November 15, 2017).

Statistics Canada. 2017a. *Table 002-0011 - Food available in Canada, annual (kilograms per person, per year unless otherwise noted) (1974 – 2016).* CANSIM (database) (accessed March 20, 2017).

Statistics Canada. 2017b. *Table 002-0011 - Food available in Canada, annual (kilograms per person, per year unless otherwise noted) (1979 – 2016).* CANSIM (database) (accessed March 20, 2017).

Statistics Canada. 2017c. *Table 002-0011 - Food available in Canada, annual (kilograms per person, per year unless otherwise noted) (1985 – 2016).* CANSIM (database) (accessed March 20, 2017).

Statistics Canada. 2017d. *Table 326-0020 - Consumer Price Index, annual (2002=100 unless otherwise noted) (1974 – 2016).* CANSIM (database) (accessed March 20, 2017).

Statistics Canada. 2017e. *Table 326-0020 - Consumer Price Index, annual (2002=100 unless otherwise noted) (1979 – 2016).* CANSIM (database) (accessed March 20, 2017).

Statistics Canada. 2017f. *Table 326-0020 - Consumer Price Index, annual (2002=100 unless otherwise noted) (1985 – 2016).* CANSIM (database) (accessed March 20, 2017).

Stein, Alexander J. and Emilio Rodriguez-Cerezo. 2008. Functional food in the European Union. Technical report series EUR 23380. Institute for Prospective Technological Studies (IPTS).

Taljaard, Pieter R., Zerihun Gudeta Alemu, and Herman D. Van Schalkwyk. 2004. The demand for meat in South Africa: an almost ideal estimation. *Agrekon* 43 (4): 430-443.

Teisl, Mario F., Nancy E. Bockstael, and Alan Levy. Measuring the Welfare Effects of Nutrition Information. *American Journal of Agricultural Economics* 83 (1): 133-49.

Teratanavat, Ratapol. and Neal H. Hooker. 2006. Consumer valuations and preference heterogeneity for a novel functional food. *Journal of Food Science* 71 (7): S533-41.

Theil, Henri. 1965. The information approach to demand analysis. *Econometrica* 33 (1): 67-87.

Thompson, Abby K., and Paul J. Moughan. 2008. Innovation in the foods industry: Functional foods. *Innovation* 10 (1): 61-73.

Thornton, James. 2002. Estimating a health production function for the US: Some new evidence. *Applied Economics* 34 (1): 59-62.

Tonsor, Glynn T., James R. Mintert, and Ted C. Schroeder. 2010. U.S. meat demand: Household dynamics and media information impacts. *Journal of Agricultural and Resource Economics* 35 (1): 1-17.

Tonsor, Glynn T., and Nicole J. Olynk. 2011. Impacts of animal Well-Being and welfare media on meat demand. *Journal of Agricultural Economics* 62 (1): 59-72.

Tseng, Hui-Kuan, and Reed Olsen. 2016. The U.S. health production function: Evidence from 2001 to 2009. *International Journal of Health Economics and Management* 16 (1): 51-64.

Urala, Nina, and Liisa Lähteenmäki. 2004. Attitudes behind consumers' willingness to use functional foods. *Food Quality and Preference* 15 (7): 793-803.

Urala, Nina, and Liisa Lähteenmäki. 2007. Consumers' changing attitudes towards functional foods. *Food Quality and Preference* 18 (1): 1-12.

U.S. Food and Drug Administration (FDA). 1998. Guidance for Industry: Notification of a Health Claim or Nutrient Content Claim Based on an Authoritative Statement of a Scientific Body. https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ucm056975.htm

U.S. Food and Drug Administration (FDA). 2003. Guidance for Industry: Trans Fatty Acids in Nutrition Labelling, Nutrient Content Claims, Health Claims; Small Entity Compliance Guide. https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm053479.htm (accessed July 27, 2017)

U.S. Food and Drug Administration (FDA). 2005. Dietary Supplement Labelling Guide: Chapter VI. Claims. https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/DietarySupplements/ucm070613.htm#6-1 (accessed September 6, 2017)

U.S. Food and Drug Administration (FDA). 2013a. Guidance for Industry: A Food Labeling Guide (8. Claims). http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm064908.htm (accessed August 2, 2016)

U.S. Food and Drug Administration (FDA). 2013b. Guidance for Industry: A Food Labeling Guide (9. Appendix A: Definitions of Nutrient Content Claims) https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm064911.htm

U.S. Food and Drug Administration (FDA). 2013c. Guidance for Industry: A Food Labeling Guide (11. Appendix C: Health Claims). http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/LabelingNutrition/ucm064919.htm (accessed July 28, 2016)

U.S. Food and Drug Administration (FDA). 2014. Summary of Qualified Health Claims Subject to Enforcement Discretion. http://www.fda.gov/Food/IngredientsPackagingLabeling/LabelingNutrition/ucm073992.htm (accessed August 2, 2016)

U.S. Food and Drug Administration (FDA). 2016a. Dietary Supplements. http://www.fda.gov/Food/DietarySupplements/ (Accessed October 5, 2016)

U.S. Food and Drug Administration (FDA). 2016b. Dietary Supplement Products and Ingredients. http://www.fda.gov/Food/DietarySupplements/ProductsIngredients/default.htm (Accessed October 5, 2016)

U.S. Food and Drug Administration (FDA). 2016c. Label Claims for Conventional Foods and Dietary Supplements. https://www.fda.gov/food/ingredientspackaginglabeling/labelingnutrition/ucm111447.htm (accessed July 4, 2017)

U.S. Food and Drug Administration (FDA). 2016d. Labeling & Nutrition. http://www.fda.gov/Food/IngredientsPackagingLabeling/LabelingNutrition/ (Accessed April 9, 2016)

U.S. Food and Drug Administration (FDA). 2016e. Labeling of Infant Formula: Guidance for Industry. Guidance Document Prepared by the Food Labeling and Standards Staff, Office of Nutrition and Food Labeling, in the Center for Food Safety and Applied Nutrition, at the U.S. Food and Drug Administration.

U.S. Food and Drug Administration (FDA). 2017. Dietary Supplements: What you Need to Know. https://www.fda.gov/Food/DietarySupplements/UsingDietarySupplements/ucm109760.htm

van Kleef, Ellen, Hans C. M. van Trijp, and Pieternel Luning. 2005. Functional foods: Health claim-food product compatibility and the impact of health claim framing on consumer evaluation. *Appetite* 44 (3): 299-308.

van Trijp, Hans C. M. and Ivo A. van der Lans. 2007. Consumer perceptions of nutrition and health claims. *Appetite* 48 (3): 305-24.

Vecchio, Riccardo, Ellen J. Van Loo, and Azzurra Annunziata. 2016. Consumers' willingness to pay for conventional, organic and functional yogurt: evidence from experimental auctions. *International Journal of Consumer Studies* 40 (3): 368-78.

Veeman, Michael. 2002. Policy development for novel foods: Issues and challenges for functional food. *Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie* 50 (4): 527-539.

Verbeke, Wim. 2005. Consumer acceptance of functional foods: socio-demographic, cognitive and attitudinal determinants. *Food quality and preference* 16 (1): 45-57.

Verbeke, Wim. 2006. Functional foods: Consumer willingness to compromise on taste for health? *Food Quality and Preference* 17 (1): 126-31.

Vicentini, A., L. Liberatore, and D. Mastrocola. 2016. Functional foods: Trends and development of the global market. *Italian Journal of Food Science* 28 (2): 338-51.

Wansink, Brian, and Matthew M. Cheney. 2005. Leveraging FDA health claims. *Journal of Consumer Affairs* 39(2): 386-98.

Waterlander, Wilma E., and Shannon N. Zenk. 2015. Food labelling, food retail availability and food pricing - moving from research to action? *Public health nutrition* 18 (1): 2-7.

Watts, Jennifer J., and Leonie Segal. 2009. Market failure, policy failure and other distortions in chronic disease markets. *BMC Health Services Research* 9 (1): 102-108.

Wolfe, Barbara, and Mary Gabay. 1987. Health status and medical expenditures: More evidence of a link. *Social Science & Medicine* 25 (8): 883-88.

World Health Organization (WHO). 2003. *Diet, nutrition, and the prevention of chronic diseases: Report of a joint WHO/FAO expert consultation*. Vol. 916. Geneva: World Health Organization.

World Health Organization (WHO). 2014. Frequently asked questions on genetically modified foods. http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/ (accessed July 19, 2017)

World Health Organization (WHO). 2017a. NCD mortality and morbidity. http://www.who.int/gho/ncd/mortality_morbidity/en/ (accessed July 7, 2017).

World Health Organization (WHO). 2017b. Tobacco. http://www.who.int/mediacentre/factsheets/fs339/en/ (accessed September 17, 2017).

Williams, Peter. 2005. Consumer understanding and use of health claims for foods. *Nutrition Reviews* 63 (7): 256-64.

Xiong, Bo, Daniel Sumner, and William Matthews. 2014. A new market for an old food: The U.S. demand for olive oil. *Agricultural Economics* 45 (1): 107-18.

Yen, Steven T., Kamhon Kan, and Shew-Jiuan Su. 2002. Household demand for fats and oils: Two-step estimation of a censored demand system. *Applied Economics* 34 (14): 1799-806.

Yen, Steven T., and Wen S. Chern. 1992. Flexible demand systems with serially correlated errors: Fat and oil consumption in the united states. *American Journal of Agricultural Economics* 74 (3): 689-97.

Yi, Haechang, Keum Taek Hwang, Joe M. Regenstein, and Sung Woo Shin. 2014. Fatty acid composition and sensory characteristics of eggs obtained from hens fed flaxseed oil, dried whitebait and/or fructo-oligosaccharide. *Asian-Australasian Journal of Animal Sciences* 27 (7): 1026-34.

Zheng, Yuqing Q., and Harry M. Kaiser. 2009. Evaluating the effectiveness of generic advertising versus nonadvertising marketing activities on New York state milk markets. *Agribusiness* 25 (3): 351-68.

APPENDIX

Appendix 1. Overview of Type of Claims by Country and Product

Country	Type of Claims	Functional Foods[a] (number of approved claims)	Natural Health Products[b]
Canada	Disease risk reduction and therapeutic claims	Generic claims[c] (16)	Product-specific claims[d]
	Function claims	Generic claims – 3 Subcategories: • Function (4) • General Nutrient Function (2) • Specific Nutrient Function Claims (67)	Product-specific claims
	Nutrient content claims	Generic claims: • 13 categories each with many variations	n/a
U.S.	Health claims	Generic claims – 3 Subcategories: • SSA Authorized[d] (12) • Qualified (18) • FDAMA Authorized claims (5)	Generic claims[f]: SSA Authorized; and Qualified
	Structure/function claims	Does not regulate these claims	Does not regulate but requires pre-market notification
	Nutrient content claims	Generic claims:	n/a
E.U.	Risk reduction claims	Generic claims (14)	Generic claims[g]
	Function claims	2 Subcategories: Generic claims: • General function claims (229) Product-specific claims: • New Function Claims (2)	Generic claims: Can use same claims as foods

Country	Type of Claims	**Functional Foods**[a] (number of approved claims)	**Natural Health Products**[b]
	Nutrition claims	Generic claims	n/a

Source: Author

Notes:

a. The U.S. does not define functional foods; instead foods with extra health benefits are regulated as conventional foods.
b. Natural health products are known as 'dietary supplements' in the U.S. and 'food supplements' in the E.U.
c. Generic claims are claims that, once approved, can be used on any product that satisfies the criteria to carry the claim.
d. Product-specific claims are reviewed on a case-by-case basis and approved for use on specific products only.
e. Claims satisfying the Significant Scientific Agreement (SSA).
f. Dietary supplements in the U.S. can use the same approved generic SSA authorized and qualified health claims as foods.
g. Food supplements in the E.U. can use the same approved generic claims as foods.

Appendix 2. Diseases Listed in Schedule A, Food and Drugs Act

- Acute alcoholism
- Acute anxiety state
- Acute infectious respiratory syndromes
- Acute psychotic conditions
- Acute, inflammatory and debilitating arthritis
- Addiction (except nicotine addiction)
- Appendicitis
- Arteriosclerosis
- Asthma
- Cancer
- Congestive heart failure
- Convulsions
- Dementia
- Depression
- Diabetes
- Gangrene
- Glaucoma
- Haematologic bleeding disorders
- Hepatitis
- Hypertension
- Nausea and vomiting of pregnancy
- Obesity
- Rheumatic fever
- Septicaemia
- Sexually transmitted diseases
- Strangulated hernia
- Thrombotic and embolic disorders
- Thyroid disease
- Ulcer of the gastro-intestinal tract

Source: Health Canada (2013)

Appendix 3. Table of Acceptable Nutrient Function Claims in Canada

Nutrient	Acceptable Nutrient Function Claims
Protein	• helps build and repair body tissues • helps build antibodies • helps build strong muscles
Fat	• supplies energy • aids in the absorption of fat-soluble vitamins
DHA	• DHA, an omega-3 fatty acid, supports the normal physical development of the brain, eyes and nerves primarily in children under two year of age
ARA	• ARA, an omega-6 fatty acid, supports the normal physical development of the brain, eyes and nerves primarily in children under two year of age
Carbohydrate	• supplies energy • assists in the utilization of fats
Vitamin A	• aids normal bone and tooth development • aids in the development and maintenance of night vision • aids in maintaining the health of the skin and membranes • contributes to the normal function of the immune system • contributes to the maintenance of normal vision • helps build strong bones and teeth • supports night vision • supports healthy skin
Vitamin D	• factor in the formation and maintenance of bones and teeth • enhances calcium and phosphorus absorption and utilization • helps build strong bones and teeth • builds and maintains strong bones and teeth • improves calcium absorption • improves calcium and phosphorus absorption
Vitamin E	• a dietary antioxidant • a dietary antioxidant that protects the fat in body tissues from oxidation
Vitamin C	• a factor in the development and maintenance of bones, cartilage, teeth and gums • a dietary antioxidant • a dietary antioxidant that significantly decreases the adverse effects of free radicals on normal physiological functions

Nutrient	Acceptable Nutrient Function Claims
	• a dietary antioxidant that helps to reduce free radicals and lipid oxidation in body tissues • factor in energy metabolism • helps build teeth, bones, cartilage and gums • protects against free radicals • protects against the damage of free radicals • protects against the oxidative effects of free radicals
Thiamine (Vitamin B1)	• releases energy from carbohydrate • aids normal growth
Riboflavin (Vitamin B2)	• factor in energy metabolism and tissue formation
Niacin	• aids in normal growth and development • factor in energy metabolism and tissue formation
Vitamin B6	• factor in energy metabolism and tissue formation
Folate	• aids in red blood cell formation • a factor in normal early fetal development • a factor in the normal early development of the fetal brain and spinal cord • contributes to normal amino acid synthesis
Vitamin B12	• aids in red blood cell formation • factor in energy metabolism
Biotin	• factor in energy metabolism
Vitamin K	• contributes to the maintenance of bones
Pantothenic Acid	• factor in energy metabolism and tissue formation
Calcium	• aids in the formation and maintenance of bones and teeth
Phosphorus	• factor in energy metabolism • factor in the formation and maintenance of bones and teeth
Magnesium	• contributes to normal muscle function • factor in energy metabolism, tissue formation and bone development
Iron	• factor in red blood cell formation

Nutrient	Acceptable Nutrient Function Claims
	• helps build red blood cells
Zinc	• contributes to the maintenance of normal skin • contributes to the normal function of the immune system • factor in energy metabolism and tissue formation
Iodine	• factor in the normal function of the thyroid gland
Selenium	• a dietary antioxidant involved in the formation of a protein that defends against oxidative stress • dietary antioxidant • helps protect against oxidative stress
Chromium	• contributes to normal glucose metabolism
Copper	• contributes to the maintenance of normal connective tissue
Manganese	• contributes to the formation and maintenance of bones • factor in energy metabolism

Source: CFIA (2016b)

Appendix 4. Acceptable Non-Strain Specific Claims for Probiotics in Canada

Eligible bacterial species **Latin name (acceptable nomenclature) and synonym where applicable**	**Acceptable Non-Strain Specific Probiotic Claim for Food**
• *Bifidobacterium adolescentis* • *Bifidobacterium animalis* subsp. *Animalis* • *Bifidobacterium animalis* subsp. *lactis* -synonym: *B. lactis* • *Bifidobacterium bifidum* • *Bifidobacterium breve* • *Bifidobacterium longum* subsp. *infantis* comb. nov. • *Bifidobacterium longum* subsp. *longum* subsp. nov. • *Lactobacillus acidophilus* • *Lactobacillus casei* • *Lactobacillus fermentum* • *Lactobacillus gasseri* • *Lactobacillus johnsonii* • *Lactobacillus paracasei* • *Lactobacillus plantarum* • *Lactobacillus rhamnosus* • *Lactobacillus salivarius*	Probiotic that naturally forms part of the gut flora. Provides live microorganisms that naturally form part of the gut flora. Probiotic that contributes to healthy gut flora. Provides live microorganisms that contribute to healthy gut flora.

Source: CFIA (2016b)

Appendix 5. Canada Health and Nutrient Content Claims

Function Claims:

- Coarse wheat bran and regularity
- Green tea and antioxidant effects
- Psyllium and regularity
- Polysaccharide complex and post-prandial blood glucose response

Sources: CFIA (2016b); Health Canada (2016d)

Disease Risk Reduction Claims:

- Vegetables and Fruit and Heart Disease (2015)
- Sugar-Free Chewing Gum and Dental Caries Risk Reduction (2014)
- Calcium and Osteoporosis (2000)
- Fruits, Vegetables and Cancer (2000)
- Dietary Fat, Saturated Fat, Cholesterol, Trans Fatty Acids and Coronary Heart Disease (2000)
- Sodium and Hypertension (2000)

Source: Health Canada (2016d)

Therapeutic Health Claims:

- Eicosapentaenoic Acid, Docosahexaenoic Acid and Triglyceride Lowering (therapeutic) (2016)
- Polysaccharide Complex (Glucomannan, Xanthan Gum, Sodium Alginate) and Cholesterol Lowering (therapeutic) (2016)
- Soy Protein and Cholesterol Lowering (therapeutic) (2015)
- Ground Whole Flaxseed and Blood Cholesterol Lowering (therapeutic) (2014)
- Barley Products and Blood Cholesterol Lowering (therapeutic) (2012)
- Unsaturated Fat and Blood Cholesterol Lowering (therapeutic) (2012)
- Psyllium Products and Blood Cholesterol Lowering (therapeutic) (2011)
- Oat Products and Blood Cholesterol Lowering (therapeutic) (2010)
- Plant Sterols (Phytosterols) (therapeutic) (2010)

Source: Health Canada (2016d)

Nutrient Content Claim Categories:

- Energy and Calorie Claims
- Protein Claims
- Fat Claims
- Saturated Fatty Acid Claims
- Trans Fatty Acid Claims
- Omega-3 and Omega-6 Polyunsaturated Fatty Acid Claims
- Cholesterol Claims
- Sodium (Salt) Claims
- Potassium Claims
- Carbohydrate and Sugars Claims
- Dietary Fibre Claims

- Vitamin and Mineral Nutrient Claims
- “Light Claims”

Source: CFIA 2016c

Appendix 6. U.S. Health and Nutrient Content Claims

<u>NLEA Authorized Health Claims</u>

- Calcium, Vitamin D, and Osteoporosis (2008)
- Stanols/Sterols and Risk of Coronary Heart Disease (2000)
- Soy Protein and Risk of Coronary Heart Disease (1999)
- Soluble Fiber from Certain Foods and Risk of Coronary Heart Disease (1997)
- Dietary Non-cariogenic Carbohydrate Sweeteners and Dental Caries (1996)
- Folic Acid and Neural Tube Defects (1996)
- Dietary Lipids (Fat) and Cancer (1993)
- Dietary Saturated Fat and Cholesterol and Risk of Coronary Heart Disease (1993)
- Fiber-containing Grain Products, Fruits and Vegetables and Cancer (1993)
- Fruits and Vegetables and Cancer (1993)
- Fruits, Vegetables and Grain Products that contain Fiber, particularly Soluble fiber, and Risk of Coronary Heart Disease (1993)
- Sodium and Hypertension (1993)

Source: FDA (2013c)

<u>FDAMA Authorized Health Claims</u>

- Whole Grain Foods and Risk of Heart Disease and Certain Cancers
- Whole Grain Foods with Moderate Fat Content and Risk of Heart Disease
- Potassium and the Risk of High Blood Pressure and Stroke
- Fluoridated Water and Reduced Risk of Dental Carries
- Saturated Fat, Cholesterol, and Trans Fat, and Reduced Risk of Heart Disease

Source: FDA (2013c)

<u>Qualified Health Claims</u>

- 100% Whey-Protein Partially Hydrolyzed Infant Formula and Reduced Risk of Atopic Dermatitis
- Tomatoes and/or Tomato Sauce and Prostate, Ovarian, Gastric, and Pancreatic Cancers
- Calcium and Colon/Rectal Cancer and Calcium and Recurrent Colon/Rectal Polyps
- Green Tea and Cancer
- Selenium and Cancer
- Antioxidant Vitamins and Cancer
- Nuts and Heart Disease
- Walnuts and Heart Disease
- Omega-3 Fatty Acids and Coronary Heart Disease
- B Vitamins and Vascular Disease
- Monounsaturated Fatty Acids from Olive Oil and Coronary Heart Disease
- Unsaturated Fatty Acids from Canola Oil and Coronary Heart Disease
- Corn Oil and Heart Disease
- Phosphatidylserine and Cognitive Dysfunction and Dementia

- Psyllium Husk and Diabetes
- Chromium Picolinate and Diabetes
- Calcium and Hypertension, Pregnancy-Induced Hypertension, and Preeclampsia
- 0.8 mg Folic Acid and Neural Tube Birth Defects

Source: FDA (2014)

Nutrient Content Claim Categories (U.S.):

- Calories Claims
- Total Fat Claims
- Saturated Fat Claims
- Cholesterol Claims
- Sodium Claims
- Sugars Claims

Source: FDA 2013b

Appendix 7. E.U. Health and Nutrient Content Claims

Function Claims:

- A list of the 229 approved function claims can be found on the EU Register on nutrition and health claims available at http://ec.europa.eu/nuhclaims/?event=search

Disease Risk Reduction Claims: (referred to as 'risk reduction claims' in the E.U.)

- Calcium, vitamin D and osteoporosis
- Vitamin D, postural instability and muscle weakness
- Monounsaturated and/or polyunsaturated fatty acids, blood cholesterol lowering and heart disease
- Folic Acid and neural tube defects
- Barley beta-glucans, blood cholesterol lowering and heart disease
- Chewing gum sweetened with 100% xylitol and dental caries
- Oat beta-glucan, blood cholesterol lowering and heart disease
- Plant sterols/Plant stanol esters, blood cholesterol lowering and heart disease
- Sugar-free chewing gum, plaque acids, and dental caries
- Sugar-free chewing gum, tooth demineralization, and dental caries

Source: EC (n.d.)

Nutrient Content Claims: (referred to as 'nutrition claims' in the E.U.)

- Energy Claims
- Fat Claims
- Saturated Fat Claims
- Sugars Claims
- Sodium Claims
- Fibre Claims
- Protein Claims
- Vitamin and Mineral Claims
- Light/Lite Claims
- Naturally/Natural Claims
- Omega-3 Claims
- Monounsaturated Fat Claims
- Polyunsaturated Fat Claims
- Unsaturated Fat Claims

Source: EC (2017d)

Appendix 8. Descriptions and Sources of Price and Quantity Data

Demand System	**Commodity**	**Quantity Data Description**	**Price Data Description**
Fats and oils (Canada)	Butter	Annual kilograms of butter available per capita *Source: Statistics Canada (2017b)*	Consumer price index for butter *Source: Statistics Canada (2017d)*
	Margarine	Annual kilograms of margarine available per capita *Source: Statistics Canada (2017b)*	Consumer price index for margarine *Source: Statistics Canada (2017d)*
	Oils	Annual kilograms of salad (vegetable) oils available per capita *Source: Statistics Canada (2017b)*	Consumer price index for 'other edible fats and oils' - This was used as a proxy for salad oils as majority of other edible fats and oils available for consumption in Canada comes from vegetable oils (salad oils) *Source: Statistics Canada (2017d)*
Meats (Canada)	Poultry	Annual kilograms of chicken, stewing hen and turkey available per capita on an eviscerated weight basis *Source: Statistics Canada (2017c)*	Consumer price index for 'fresh and frozen poultry' *Source: Statistics Canada (2017e)*
	Pork	Annual kilograms of pork available per capita on a retail weight basis *Source: Statistics Canada (2017c)*	Consumer price index for 'fresh or frozen pork' *Source: Statistics Canada (2017e)*

Demand System	Commodity	Quantity Data Description	Price Data Description
	Beef	Annual kilograms of beef and veal available per capita on a retail weight basis *Source: Statistics Canada (2017c)*	Consumer price index for 'fresh and frozen beef' *Source: Statistics Canada (2017e)*
Fruits and Vegetables[a] (Canada)	Fresh fruit	Total annual kilograms of fresh fruit available per capita *Source: Statistics Canada (2017c)*	Consumer price index for fresh fruit *Source: Statistics Canada (2017f)*
	Preserved fruit	Total annual kilograms of fruit juices, canned fruit, frozen fruit and dried fruit available per capita *Source: Statistics Canada (2017c)*	Consumer price index for preserved fruit and fruit preparations *Source: Statistics Canada (2017f)*
	Fresh vegetables	Total annual kilograms of fresh vegetables available per capita *Source: Statistics Canada (2017c)*	Consumer price index for fresh vegetables *Source: Statistics Canada (2017f)*
	Preserved vegetables	Total annual kilograms of vegetable juices, canned vegetables and frozen vegetables available per capita *Source: Statistics Canada (2017c)*	Consumer price index for preserved vegetables and vegetable preparations *Source: Statistics Canada (2017f)*
Fats (United States)	Butter	Annual pounds of butter available per capita *Source: ERS (2017d)*	Consumer price index for poultry *Source: BLS (2017a)*
	Margarine	Annual pounds of margarine available per capita *Source: ERS (2017b)*	Consumer price index for fresh or frozen pork *Source: ERS (2017b)*

Demand System	Commodity	Quantity Data Description	Price Data Description
	Lard	Annual pounds of lard available per capita *Source: ERS (2017c)*	Consumer price index for beef and veal *Source: ERS (2017c)*
Meats (United States)	Poultry	Annual pounds of chicken, broilers and turkey available per capita on an eviscerated weight basis *Source: ERS (2017a)*	Consumer price index for poultry *Source: BLS (2017b)*
	Pork	Annual pounds of pork available per capita on a retail weight basis *Source: ERS (2017a)*	Consumer price index for fresh or frozen pork *Source: BLS (2017c)*
	Beef	Annual pounds of beef and veal available per capita on a retail weight basis *Source: ERS (2017a)*	Consumer price index for beef and veal *Source: BLS (2017d)*

Source: Author

Notes:

a. See Table A.3 for a list of the commodities included in each of the fruits and vegetables categories.

Appendix 9. Fruits and Vegetables Available in Canada by Category[a]

Fresh Fruits	Preserved Fruits	Fresh Vegetables	Preserved Vegetables
Apples	Apples canned	Artichokes	Asparagus canned
Apricots	Apples dried	Asparagus	Beans green and wax canned
Avocados	Apples frozen	Beans green and wax	Beans green and wax frozen
Bananas	Apple juice	Beets	Beets canned
Other fresh berries	Apple pie filling	Broccoli	Broccoli frozen
Blueberries	Apple sauce	Brussels sprouts	Brussels sprouts frozen
Cherries	Apricots canned	Cabbage	Carrots canned
Coconut	Blueberries canned	Carrots	Carrots frozen
Cranberries	Blueberries frozen	Cauliflower	Cauliflower frozen
Dates	Cherries frozen	Celery	Corn canned
Figs	Grape juice	Corn	Corn frozen
Grapes	Peaches canned	Cucumbers	Mushrooms canned
Melons	Pears canned	Other edible roots	Peas canned
Other fresh melons	Pineapples canned	Eggplants	Peas frozen
Watermelons	Pineapple juice	Garlic	Spinach frozen
Wintermelons	Raspberries frozen	Kohlrabi	Tomatoes canned
Nectarines	Strawberries canned	Leeks	Tomato juice
Peaches	Strawberries frozen	Lettuce	Tomatoes, pulp, paste and puree
Pears	Fruits not specified dried	Manioc	Vegetables not specified canned
Pineapples	Fruits not specified frozen	Mushrooms	
Plums	Orange juice	Okra	
Strawberries	Lemon juice	Olives	
Fruits not specified	Grapefruit juice	Onions and shallots	
Oranges		Parsley	
Lemons		Parsnips	
Grapefruits		Peas	
Limes		Peppers	
		Pumpkins and squash	
		Radishes	
		Rappini	
		Rutabagas and turnips	
		Spinach	
		Tomatoes	

Source: Author

Notes:

a. Based on per capita domestic disappearance data available for the years 1979 to 2016 in Statistics Canada`s Food Available in Canada, CANSIM table 002-0011

Appendix 10. Description of Variables Included in the Population Health Analysis

Variable	Definition	Original Measurements
$LE65_{Male}$	Male life expectancy at age 65 in years	none
$LE65_{Female}$	Female life expectancy at age 65 in years	none
SMOKE	Annual kilograms of tobacco consumed per capita, age 15 years or older	Originally measured in grams. Divided by 1000 to convert to annual kilograms of tobacco consumed per capita
DRINK	Annual liters of alcohol consumed per capita, age 15 years and older	none
FAT	Annual grams of fat consumed per capita	Originally in daily units. Multiplied by 365 and divided by 1000 to convert to annual kg per capita
FV	Annual kilograms of fruits and vegetables consumed per capita	Sum of annual kilograms of fruit and annual kilograms of vegetables per capita
GDP	GDP per capita measured in U.S. dollars, constant prices, constant exchange rates, OECD base year (2010)	none
EDUC	Share of population age 25 to 64 with at least upper secondary education	none
DOC	Professionally active physicians measured as density per 1000 population	none
POL	Annual nitrous oxide emissions per capita	none
CANADA	Binary variable taking on the value 1 if country is Canada and 0 otherwise	n/a

Source: Author